# TRANSACTIONS

## The American Fisheries Society

1939

[illegible]TH ANNUAL MEETING
SAN FRANCISCO, CALIFORNIA
JUNE 26 [illegible] 27, 1939

# Transactions

of the

# American Fisheries Society

SIXTY-NINTH ANNUAL MEETING

SAN FRANCISCO, CALIFORNIA

JUNE 26 AND 27, 1939

Published Annually by the Society
Washington, D. C.
1940

*Printed in the U. S. A.*

*Manuscripts are accepted with the understanding that they shall not be submitted for publication elsewhere in the original or in a slightly modified form prior to their appearance in the published* TRANSACTIONS, *and with the further understanding that all republications shall give proper credit to the* TRANSACTIONS.

EDITED BY THE PUBLICATIONS COMMITTEE FOR 1939-1940

John Van Oosten, *Chairman*

Paul R. Needham — Ralph Hile

Lauren R. Donaldson — Hilary J. Deason

# THE AMERICAN FISHERIES SOCIETY

**Organized 1870** **Incorporated 1910**

---

The Society was organized to promote the cause of fish culture; to gather and diffuse information of a scientific character; and to unite and encourage those interested in fish culture and fisheries problems.

---

## OFFICERS FOR 1938-1939

*President* ........ Fred J. Foster, Seattle, Wash.
*First Vice-President* ........ T. H. Langlois, Put-in-Bay, Ohio
*Second Vice-President* ........ James Brown, Frankfort, Ky.
*Secretary-Treasurer* ........ Seth Gordon, Harrisburg, Pa.
*Librarian* ........ Kenneth E. Cobb, Windsor Locks, Conn.

### Vice-Presidents of Divisions

*Fish Culture* ........ H. H. MacKay, Toronto, Canada
*Aquatic Biology and Physics* ........ L. R. Donaldson, Seattle, Wash.
*Commercial Fishing* ........ H. J. Deason, Ann Arbor, Mich.
*Protection and Legislation* ........ William C. Adams, Albany, N. Y.
*Angling* ........ C. R. Gutermuth, Indianapolis, Ind.

## OFFICERS FOR 1939-1940*

*President* ........ T. H. Langlois, Put-in-Bay, Ohio
*First Vice-President* ........ James Brown, Frankfort, Ky.
*Second Vice-President* ........ John Van Oosten, Ann Arbor, Mich.
*Secretary-Treasurer* ........ Seth Gordon, Harrisburg, Pa.
**Address all routine mail to the Secretary, Investment Bldg., Washington, D. C.**
*Librarian* ........ Kenneth E. Cobb, Windsor Locks, Conn.

### Vice-Presidents of Divisions

*Fish Culture* ........ M. C. James, Washington, D. C.
*Aquatic Biology and Physics* ........ A. R. Cahn, Norris, Tenn.
*Commercial Fishing* ........ Herbert C. Davis, San Francisco, Calif.
*Protection and Legislation* ........ I. T. Quinn, Washington, D. C.
*Angling* ........ David H. Madsen, Salt Lake City, Utah

---

***For street address see membership list.**

## STANDING COMMITTEES, 1939-1940

### EXECUTIVE COMMITTEE

The Executive Committee consists of the president, vice-presidents, secretary, librarian, vice-presidents of divisions, and Fred J. Foster, the president last year.

### COMMITTEE ON FOREIGN RELATIONS

| | |
|---|---|
| A. G. HUNTSMAN, *Chairman* | Toronto, Canada |
| WILLIAM C. ADAMS | Albany, N. Y. |
| B. M. BRENNAN | Seattle, Wash. |
| CHARLES E. JACKSON | Washington, D. C. |
| WILLIAM J. TUCKER | Austin, Tex. |
| B. O. WEBSTER | Madison, Wis. |
| SEÑOR JUAN ZINSER | Mexico City, Mexico |

### COMMITTEE ON THE COMMON AND SCIENTIFIC NAMES OF FISHES

| | |
|---|---|
| WALTER H. CHUTE, *Chairman* | Chicago, Ill. |
| W. A. CLEMENS | Nanaimo, B. C., Canada |
| JAMES NELSON GOWANLOCH | New Orleans, La. |
| SAMUEL F. HILDEBRAND | Washington, D. C. |
| CARL L. HUBBS | Ann Arbor, Mich. |
| GEORGE S. MYERS | Stanford University, Calif. |
| LEONARD P. SCHULTZ | Washington, D. C. |

## SPECIAL COMMITTEES

### Committee on American Fish Policy

| | |
|---|---|
| E. L. Wickliff, *Chairman* | Columbus, Ohio |
| J. D. Chalk | Raleigh, N. C. |
| H. S. Davis | Washington, D. C. |
| Seth Gordon | Harrisburg, Pa. |
| John R. Greeley | Albany, N. Y. |
| Wm. J. K. Harkness | Toronto, Canada |
| A. S. Hazzard | Ann Arbor, Mich. |
| Carl L. Hubbs | Ann Arbor, Mich. |
| A. G. Huntsman | Toronto, Canada |
| S. B. Locke | Boston, Mass. |
| Paul R. Needham | Palo Alto, Calif. |
| James A. Rodd | Ottawa, Canada |
| Clarence M. Tarzwell | Decatur, Ala. |
| John Van Oosten | Ann Arbor, Mich. |
| Geo. C. Warren, Jr. | Summit, N. J. |

### Committee on Pollution Study

| | |
|---|---|
| Harry B. Hawes, *Hon. Chairman* | Washington, D. C. |
| M. M. Ellis, *Chairman* | Columbia, Mo. |
| Talbott Denmead, *Secretary* | Washington, D. C. |
| Milton P. Adams | East Lansing, Mich. |
| C. M. Baker | Madison, Wis. |
| Charles A. French | Ellwood City, Pa. |
| S. B. Locke | Boston, Mass. |
| C. C. Regan | Covington, Ky. |
| Kenneth A. Reid | Chicago, Ill. |
| James A. Rodd | Ottawa, Canada |
| Carl D. Shoemaker | Washington, D. C. |
| W. F. Thompson | Seattle, Wash. |
| John Van Oosten | Ann Arbor, Mich. |
| Henry B. Ward | Urbana, Ill. |

## PRESIDENTS' TERMS OF SERVICE AND PLACES OF MEETING

The first meeting of the Society occurred December 20, 1870. The organization then effected continued until February, 1872, when the second meeting was held. Since that time there has been a meeting each year, as shown below. The respective presidents were elected at the meeting, at the place, and for a period shown opposite their names, but they presided at the subsequent meeting.

| | | | |
|---|---|---|---|
| 1. | William Clift | 1870-1872 | New York, N. Y. |
| 2. | William Clift | 1872-1873 | Albany, N. Y. |
| 3. | William Clift | 1873-1874 | New York, N. Y. |
| 4. | Robert B. Roosevelt | 1874-1875 | New York, N. Y. |
| 5. | Robert B. Roosevelt | 1875-1876 | New York, N. Y. |
| 6. | Robert B. Roosevelt | 1876-1877* | New York, N. Y. |
| 7. | Robert B. Roosevelt | 1877-1878 | New York, N. Y. |
| 8. | Robert B. Roosevelt | 1878-1879 | New York, N. Y. |
| 9. | Robert B. Roosevelt | 1879-1880 | New York, N. Y. |
| 10. | Robert B. Roosevelt | 1880-1881 | New York, N. Y. |
| 11. | Robert B. Roosevelt | 1881-1882 | New York, N. Y. |
| 12. | George Shepard Page | 1882-1883 | New York, N. Y. |
| 13. | James Benkard | 1883-1884 | New York, N. Y. |
| 14. | Theodore Lyman | 1884-1885 | Washington, D. C. |
| 15. | Marshall McDonald | 1885-1886 | Washington, D. C. |
| 16. | W. M. Hudson | 1886-1887 | Chicago, Ill. |
| 17. | William L. May | 1887-1888 | Washington, D. C. |
| 18. | John Bissell | 1888-1889 | Detroit, Mich. |
| 19. | Eugene G. Blackford | 1889-1890 | Philadelphia, Pa. |
| 20. | Eugene G. Blackford | 1890-1891 | Put-in-Bay, Ohio |
| 21. | James A. Henshall | 1891-1892 | Washington, D. C. |
| 22. | Herschel Whitaker | 1892-1893 | New York, N. Y. |
| 23. | Henry C. Ford | 1893-1894 | Chicago, Ill. |
| 24. | William L. May | 1894-1895 | Philadelphia, Pa. |
| 25. | L. D. Huntington | 1895-1896 | New York, N. Y. |
| 26. | Herschel Whitaker | 1896-1897 | New York, N. Y. |
| 27. | William L. May | 1897-1898 | Detroit, Mich. |
| 28. | George F. Peabody | 1898-1899 | Omaha, Nebr. |
| 29. | John W. Titcomb | 1899-1900 | Niagara Falls, N. Y. |
| 30. | F. B. Dickerson | 1900-1901 | Woods Hole, Mass. |
| 31. | E. E. Bryant | 1901-1902 | Milwaukee, Wis. |
| 32. | George M. Bowers | 1902-1903 | Put-in-Bay, Ohio |
| 33. | Frank N. Clark | 1903-1904 | Woods Hole, Mass. |
| 34. | Henry T. Root | 1904-1905 | Atlantic City, N. J. |
| 35. | C. D. Joslyn | 1905-1906 | White Sulphur Springs, W. Va. |

*A special meeting was held at the Centennial Grounds, Philadelphia, Pa., October 6 and 7, 1876.

| | | |
|---|---|---|
| 36. E. A. Birge | 1906-1907 | Grand Rapids, Mich. |
| 37. Hugh M. Smith | 1907-1908 | Erie, Pa. |
| 38. Tarleton H. Bean | 1908-1909 | Washington, D. C. |
| 39. Seymour Bower | 1909-1910 | Toledo, Ohio |
| 40. William E. Meehan | 1910-1911 | New York, N. Y. |
| 41. S. F. Fullerton | 1911-1912 | St. Louis, Mo. |
| 42. Charles H. Townsend | 1912-1913 | Denver, Colo. |
| 43. Henry B. Ward | 1913-1914 | Boston, Mass. |
| 44. Daniel B. Fearing | 1914-1915 | Washington, D. C. |
| 45. Jacob Reighard | 1915-1916 | San Francisco, Calif. |
| 46. George W. Field | 1916-1917 | New Orleans, La. |
| 47. Henry O'Malley | 1917-1918 | St. Paul, Minn. |
| 48. M. L. Alexander | 1918-1919 | New York, N. Y. |
| 49. Carlos Avery | 1919-1920 | Louisville, Ky. |
| 50. Nathan R. Buller | 1920-1921 | Ottawa, Canada |
| 51. William E. Barber | 1921-1922 | Allentown, Pa. |
| 52. Glen C. Leach | 1922-1923 | Madison, Wis. |
| 53. George C. Embody | 1923-1924 | St. Louis, Mo. |
| 54. Eben W. Cobb | 1924-1925 | Quebec, Canada |
| 55. Charles O. Hayford | 1925-1926 | Denver, Colo. |
| 56. John W. Titcomb | 1926-1927 | Mobile, Ala. |
| 57. Emmeline Moore | 1927-1928 | Hartford, Conn. |
| 58. C. F. Culler | 1928-1929 | Seattle, Wash. |
| 59. David L. Belding | 1929-1930 | Minneapolis, Minn. |
| 60. E. Lee LeCompte | 1930-1931 | Toronto, Canada |
| 61. James A. Rodd | 1931-1932 | Hot Springs, Ark. |
| 62. H. S. Davis | 1932-1933 | Baltimore, Md. |
| 63. Fred A. Westerman | 1933-1934 | Columbus, Ohio |
| 64. E. L. Wickliff | 1934-1935 | Montreal, Canada |
| 65. Frank T. Bell | 1935-1936 | Tulsa, Okla. |
| 66. A. G. Huntsman | 1936-1937 | Grand Rapids, Mich. |
| 67. I. T. Quinn | 1937-1938 | Mexico City, Mexico |
| 68. Fred J. Foster | 1938-1939 | Asheville, N. C. |
| 69. T. H. Langlois | 1939-1940 | San Francisco, Calif. |

# TABLE OF CONTENTS



## PART I. BUSINESS SESSIONS

## PART II. PAPERS AND DISCUSSIONS

## APPENDICES

# PART I
# BUSINESS SESSIONS

co
S
W

C
s

f

A
A

# TRANSACTIONS

## of the Sixty-ninth Annual Meeting of the

## AMERICAN FISHERIES SOCIETY

### San Francisco, California

### June 26 and 27, 1939

The Sixty-ninth Annual Meeting of the American Fisheries Society convened at 9:45 a.m., June 26, 1939, at the Sir Francis Drake Hotel, San Francisco, California, the President, Fred J. Foster, of Seattle, Washington, presiding.

The meetings were held in cooperation with the Thirty-third Annual Convention of the International Association of Game, Fish and Conservation Commissioners.

The registered attendance of members, delegates and guests was as follows:

#### Registered Members in Attendance

Alderson, I. T., Missouri.
Aldrich, A. D., Oklahoma.

Bode, I. T., Missouri.
Bonnot, Paul, California.
Bostwick, William, California.
Botinovich, Matt, California (Rep. United Fisherman's Union).
Boyd, W. W., Texas (Rep. Tex. Game, Fish and Oyster Com.).
Brown, Merrill, California.
Butler, George E., Canada.

Chalk, J. D., North Carolina (Rep. N. C. Div. of Game and Inland Fisheries).
Chapman, W. M., Washington.
Chute, W. H., Illinois.
Clanton, D. A., California.
Clark, Arthur L., Missouri.
Clark, G. H., California.
Croker, Richard, California.
Curtis, Brian, California.

Daspit, A. P., Louisiana (Rep. La. Dept. of Cons.).
Davis, H. S., District of Columbia.
Davis, Herbert C., California.
Day, Albert M., District of Columbia.
Denmead, Talbott, Maryland.
Dent, Thomas J., New Hampshire (Rep. N. H. Fish and Game Com.).
Dill, William A., California.
Donaldson, L. R., Washington.

Fish, Frederic F., Washington.
Foster, Charles R., Washington.
Foster, Fred J., Washington.

Gibbs, John T., New York (Rep. N. Y. Cons. Dept.).
Gordon, Seth, Pennsylvania.
Graves, D. N., Arkansas.
Griffiths, Francis P., Oregon.

Hatton, S. Ross, California.
Herndon, G. B., Missouri.
Hoffmaster, P. J., Michigan.
Hogan, Joe, Arkansas.
Holland, R. P., New York.
Hubbs, Carl L., Michigan.
Hunter, R. P., Connecticut.
Hutton, M. L., Iowa.

Jacocks, C. West, South Carolina.
Johnson, J., New Mexico.
Jones, Walter B., Alabama (Rep. Ala. Dept. of Cons. of Game, Fish and Seafoods).

Langlois, Thos. H., Ohio.
Leach, C. H., Oregon.
LeGear, Harry, Washington (Rep. Wash. State Game Com.).
Leitritz, Earl, California.
Leonard, J. W., Michigan.
Lewis, J. C., California.
Lewis, R. C., California.
Locke, S. B., Massachusetts.
Looff, A. T., Washington.
Loutit, W. H., Michigan.
Lynch, Thos. J., Illinois (Rep. Ill. Dept. of Cons.).

McCauley, Bernard T., Washington (Rep Wash. State Game Com.).
McCloud, George, California.

McCully, Howard, California.
MacKay, H. H., Canada.
MacKenzie, H. W., Wisconsin (Rep. Wis. Cons. Dept.).
Maclay, David J., Montana.
Madsen, David H., Utah.
Marchins, O. T., California (Rep. United Fishermen's Union).
Markus, Henry C., New York.
Merritt, J. M., Nebraska.
Mottley, W. Douglas, Canada.
Myers, George S., California.

Needham, Paul R., California.

Parvin, Roland G., Colorado (Rep. Colo. Game and Fish Com.).
Pautzke, C. F., Washington.
Peacock, A. B., Oregon.
Peck, Mrs. Hal C., Texas (Rep. Tex. Game, Fish and Oyster Com.).
Poe, J. Charles, Tennessee (Rep. Tenn. Dept. of Cons.).
Pritchard, A. L., Canada.

Quinn, I. T., District of Columbia.

Randle, Allan C., California.
Rich, Willis H., Oregon and California.
Ruhl, H. D., Michigan (Rep. Mich. Com. of Cons.).

Sawtelle, W. H., Arizona (Rep. Ariz. Game and Fish Com.).
Scofield, N. B., California.
Scofield, W. L., California.
Scott, John W., Wyoming.
Seale, Alvin, California.
Shapovalov, Leo, California.
Shaw, Paul A., California.
Shawhan, H. W., West Virginia.
Shoemaker, Carl D., District of Columbia.
Simon, James, Wyoming.
Smith, Osgood, California.

Taft, A. C., California.
Thomas, David, California (Rep. United Fishermen's Union).
Thompson, Fred A., New Mexico.
Tucker, William J., Texas.
Turner, K. D., Oklahoma (Rep. Okla. Game and Fish Com.).

Van Oosten, John, Michigan.
Vestal, Elden, California.
Vogt, James H., California.

Wales, J. H., California.
Westerman, Fred A., Michigan.
Wilson, E. E., Oregon (Rep. Ore. Game Com.).
Wire, F. B., Oregon (Rep. Ore. Game Com.).
Wright, Edgar, Mississippi (Rep. Miss. Game and Fish Com.).
Wright, Stillman, Utah.

Zinser, Juan, Mexico.

## Registered Guests in Attendance

Alderson, Mrs. I. T., Missouri.
Aldrich, Mrs. A. D., Oklahoma.
Allen, Robert, California.
Aplin, John A., California.
Ashley, G.

Bagley, Mrs. Lester, Montana.
Barr, A. C., Nevada.
Bauder, C. S., California.
Baughey, Robert M., California.
Bejarno, Jose, Mexico.
Blake, Clyde M.
Bode, Mrs. I. T., Missouri.

Callaghan, F. P., District of Columbia.
Cardenas, C., Mexico.
Catlin, Mark S., Wisconsin.
Chalk, Mrs. J. D., North Carolina.
Chappell, LaRue F., California.
Chisholm, W. F.
Chute, Mrs. W. H., Illinois.
Clark, Frances, California.
Clark, Mrs. G. H., California.
Conner, Miss G., California.
Cowsert, W. E., Texas.
Cronemiller, F. P., California.
Crouch, W. E., District of Columbia.

Dado, S. H., California.
Davis, Mrs. Herbert C., California.
Dwyer, Robert, California.

Farley, John L., California.
Fry, Donald, California.
Fulton, Kenneth I., California.

Gabrielson, Ira N., District of Columbia.
Garrett, Ethel, California.
Gatlin, John C., New Mexico.

Haecker, Harold, California.
Hennessy, Wm. J., Illinois.
Hoffmaster, Mrs. P. J., Michigan.
Horn, E. E., California.
Huddleson, Lee, Nebraska.
Hunter, J. S., California.
Hunter, Mrs. R. P., Connecticut.

Jansen, John, California.
Joy, M. F., Jr., California.
Junior Game Patrol Troop 2.
Junior Game Patrol Girls' Troop 2.

Laythe, Leo, Colorado.
Laythe, Mrs. Leo, Colorado.
Leach, Glen C., District of Columbia.
Leonard, Mrs. J. W., Michigan.
Ligon, J. Stokley, New Mexico.
Lincoln, Frederick C., District of Columbia.
Loutit, Mrs. W. H., Michigan.
Lowe, Wm. J., North Dakota.

McConaha, J. C.
Macaulay, E. L., California.
Maurek, Burnie W., Nebraska.
Moore, Roy, Louisiana.
Morphy, Alberto Alvarez, Mexico.
Munro, J. A., Canada.

Nemanic, Wm. N., Colorado.

Pautzke, Mrs. C. F., Washington.
Piver, John C., California.
Powell, William A., Jr., Nevada.
Price, B. L., Montana.

Robert, F.
Rolph, James, III, California.
Rosen, M. N., California.
Ross, George J., Virginia.
Ross, Mrs. Grace H., Virginia.

Sack, Ivan, California.
Schneider, R. W., District of Columbia.
Shantz, H. L., District of Columbia.
Shawhan, Mrs. H. W., West Virginia.
Silver, James, Georgia.
Simon, Mrs. James, Wyoming.
Smith, Cooper, California.
Snow, William S., Virginia.
Spencer, John, California.
Stras, B. W., Jr., Virginia.
Strathmere, Eric.

Talbott, M. O., California.
Tonkin, George, Iowa.
True, Gordon H., Jr., California.

Van Oosten, Mrs. John, Michigan

Watson, Harold, California.
Watson, Lew, Washington.
Westerman, Mrs. Fred A., Michigan
Whiteman, H. G.
Willford, B. C., California.
Wire, Mrs. F. B., Oregon.
Witney, William, Utah.
Worcester, Hugh, California.
Wright, Mrs. Stillman, Utah.

Young, E. C., Canada.

# OPENING ADDRESS

Fred J. Foster, President

Sixty-nine years ago the founders of the American Fisheries Society met for the first time in the City of New York. They were earnest men with a purpose. They founded what today is the oldest conservation society on our continent.

The Society and its accomplishments have seldom, if ever, been of spectacular character. The fact that the organization has weathered the year in sound health is not only a tribute to its founders and to those who have guided the destinies of the Society down through the years, but is a testimony of the substantial service of the Society to mankind.

I am sure that the founders of this Society would view with satisfaction the steady, substantial and dignified contribution it has made to the scientific knowledge and practical maintenance of our fisheries resources.

These same founders would, however, view with disappointment our failure to effect the rehabilitation of certain fisheries, notably the shad and salmon fisheries of the Atlantic Coast, the need for which was recognized even in that day. They would also view with concern the problems with which we are now faced in the Great Lakes, the Columbia, Sacramento, and others of our rivers, and in the thousands of depleted inland waters.

But we may take courage that many of these problems, serious and difficult as they are, may be solved as have been those of the restoration and maintenance of the halibut of the North Pacific and the Alaska seal and the Alaska salmon fisheries. Outstanding success has also been obtained in the management of certain inland waters. Therefore, with due and serious recognition of our present problems and limitations, let us go forward earnestly and confidently to greater knowledge and achievement.

Our needs for greater knowledge and the application of such knowledge are many. There is urgent need for an expansion of studies of certain hard-pressed commercial species and related aquatic life. Other species, not yet depleted, the catch of which is increasing, should have immediate study so that we may lock the door before the horse is stolen.

Continued studies in nutrition, disease prevention and control, and selective breeding must go forward with renewed vigor and expansion.

The management of inland waters and lake and stream surveys require a greater number of biologists capable of correctly interpreting the field data obtained.

Able and far-sighted administrators must make better use of knowledge already at hand and put into practical use whatever knowledge results from future studies. While progress has been made there is still too great a gap between the knowledge of the scientist and its practical application in hatchery production and fish distribution.

Administrators must also strive more earnestly for better cooperation between agencies and for the unification and enforcement of adequate regulations in interstate and international waters.

The papers to be presented at this meeting will help us on our way to many of the above objectives.

Ours is a most worthy cause—to help make life more abundant and more enjoyable to many millions of our people. From barefoot boys to captains of industry, noted educators, and presidents, some eight to ten millions enjoy the sport of fishing. We are told that the number of fishermen exceeds the number of persons that follow any other recreation. Also, a substantial portion

of our population is directly and indirectly dependent upon the maintenance of our commercial fisheries.

Let us always keep before us the object of this Society, "to promote the cause of fish culture; to gather and diffuse information of a scientific character; and to unite and encourage those interested in fish culture and fisheries problems," to the end that the ever increasing number of sport fishermen may enjoy to the fullest their days of recreation in God's out-of-doors, and that those dependent upon our commercial fisheries may never experience the tragedies of life which accompany the depletion of any natural resource, but through wise management may enjoy the financial security provided by a sustained yield of our commercial aquatic life.

It is appreciated that some of those present can remain in California but a few days and will wish to see something of the remarkable World's Fair on Treasure Island, the Aquarium at Golden Gate Park, and other numerous points of interest in this beautiful, cordial and altogether delightful city of San Francisco and its vicinity.

It is hoped that you will be able to visit the various places of interest and still maintain a good attendance at our sessions, which attendance will be greatly appreciated by your officers and by those who have gone to considerable effort to prepare papers and reports. I am aware that regular attendance at the sessions will require the exercise of considerable moral courage.

Some have expressed doubt as to the wisdom of holding our meetings at a point where other attractions are so unusually appealing. The attendance at our meetings here in San Francisco may well form a guide to time and place committees in formulating their recommendations to hold future meetings under similar conditions.

I hope you will have a most enjoyable time while here and let your conscience be your guide in the attendance at meetings, but please do not put your conscience in a sack and toss it into San Francisco Bay en route to Treasure Island!

# REPORTS OF OFFICERS

## REPORT OF THE SECRETARY-TREASURER
### For the Year 1938-1939

SETH GORDON

The American Fisheries Society has made very encouraging progress during the past year. From the standpoint of adding new members to the rolls, the Society did better than the previous year. We added 99 active members, 6 libraries, 2 clubs and dealers, and 6 state memberships, a total of 113 of the several classes. This is fifteen more new members than the number acquired last year.

President Foster again has been especially active in the enrollment of members, as has Mr. Alan C. Taft. Numerous other members also did their part to bring the work of the Society to the attention of fisheries workers.

While we added more new members to our roster during the year, our losses were greater than during the previous year. Through death we lost seven of our fellow workers, and it was necessary to drop eighty-five for non-payment of dues. Twelve members resigned, and our net gain for the year was only nine. Because the annual meeting was again held before the end of the fiscal year, it was necessary to close the books on June 15, and without doubt some delinquents who had to be dropped would have paid their dues before the regular closing date, thereby avoiding the lapsing of their memberships. A later closing date would have enabled us to show a still larger gain.

Your secretary regrets to report that we do not seem to be holding the interest of the new members as we should. The average period of their membership is entirely too short. Of the eighty-five dropped for dues, thirty-two, or 40 per cent, paid dues for only one year. It would be desirable to learn, if possible, the reason for this apparent lack of continuing interest. Possibly more prompt delivery of the Annual Transactions might help to assure their continuance with the Society for longer periods.

Speaking of the Transactions, your Committee on Publications has done an even more painstaking job of editing and proof reading on the sixty-eighth volume than was done the previous year, and has revamped certain parts of the volume so as to make it still better. This additional work, including the checking of proofs by authors, has delayed the volume longer than anticipated. However, an examination of the papers submitted for this meeting indicates that the authors are adhering more closely to the instructions for the preparation thereof, and the editorial work should be expedited considerably in the future.

With the approval of your president, the volume covering the meeting last year at Asheville is being printed on slightly different stock to obviate the need for special half-tone inserts. The cost is reduced thereby, and the work expedited. It is hoped that the members will find the new volume, which should be in your hands in a few days, entirely satisfactory.

Your officers and the executive committee have been active during the year in the study of various possibilities for meeting dates, consolidation of meetings with other conservation organizations, etc. A joint meeting with the officers and executive committee of the International Association of Game, Fish and Conservation Commissioners was held in Detroit during February, and in June another special conference was held in Washington, D. C. In both of these conferences it was very evident that many obstacles would prevent the holding of our annual meetings in conjunction with organizations other than the International Association, but that, as expressly desired by the majority of the Society's membership, it would not be difficult to change the

meeting dates to late August or early September. (NOTE: See Time and Place Committee report in business sessions).

Now for our financial status. Your secretary is happy to report that the financial condition of the Society is stronger than it was this time last year. The balance in the bank, when the books were closed on June 15, was $1,544.11, while last year it was only $746.79. Since the printing of the Transactions is not yet completed, that bill has not been presented, but this condition also prevailed a year ago. The bill for indexing the 68th volume was not presented until after the books were closed, but that is the only unpaid item on hand at this time.

During the year the Society added nine government baby bonds to its permanent fund holdings, having invested $487.50 of the Permanent Fund income. Last night your Executive Committee authorized the investment of $750.00 more in like securities.

The details of our income and expenditures are as follows:

## TREASURER'S REPORT
### June 16, 1938 to June 15, 1939[1]

### GENERAL FUND

| | | |
|---|---|---|
| RECEIPTS | | |
| Balance on hand June 15, 1938 | | $ 746.79 |
| Annual dues: | | |
| Individuals | | |
| For the year 1936-1937 | $ 18.00 | |
| 1937-1938 | 141.00 | |
| 1938-1939 | 1,245.00 | |
| 1939-1940 | 216.00 | |
| 1940-1941 | .50 | 1,620.50 |
| Libraries | | |
| For the year 1937-1938 | 20.00 | |
| 1938-1939 | 68.00 | |
| 1939-1940 | 4.00 | 92.00 |
| Clubs and dealers | | |
| For the year 1937-1938 | 10.00 | |
| 1938-1939 | 125.00 | |
| 1939-1940 | 30.00 | 165.00 |
| State membership | | |
| For the year 1937-1938 | 80.00 | |
| 1938-1939 | 680.00 | |
| 1939-1940 | 60.00 | 820.00 |
| General expense | | 3.00 |
| Sale of Transactions | | 220.74 |
| Sale of separates: | | |
| 1936 Transactions | 19.78 | |
| 1937 Transactions | 325.95 | 345.73 |
| Sale of Index | | 14.00 |
| Exchange on checks | | .33 |
| Transferred from Permanent Fund to be invested in Government Bonds | | 487.50 |
| Total receipts | | $4,515.59 |

[1]Since the annual meeting was advanced to June it was necessary to close the books on June 15, 1939.

| | | |
|---|---|---|
| **DISBURSEMENTS** | | |
| Transactions: | | |
| 1937, Vol. 67 | | |
| Proof reading | $ 75.00 | |
| Indexing | 79.56 | |
| Printing | 1,247.42 | |
| Reprints | 324.14 | $1,726.12 |
| 1938, Vol. 68 | | |
| Reporting | 114.90 | |
| Reprints | 3.97 | 118.87 |
| Clerical and secretarial expense: | | |
| Seth Gordon | 100.00 | |
| Ethel M. Quee | 200.00 | |
| Extra assistance | 10.44 | 310.44 |
| Postage | | 160.02 |
| Express | | 35.50 |
| Office supplies | | .45 |
| Telephone and telegraph | | 5.64 |
| Exchange on checks | | 2.73 |
| Rental safety deposit box | | 5.50 |
| Purchase of Government Baby Bonds | | 487.50 |
| General expenses | | 12.20 |
| Stationery and printing | | 87.76 |
| Premium on bond | | 18.75 |
| Total disbursements | | $2,971.48 |
| Total receipts, General Fund | 4,515.59 | |
| Total disbursements, General Fund | 2,971.48 | |
| Balance in bank, June 15, 1939 | | $1,544.11 |
| Balance in petty cash fund | | 5.00 |
| Balance on hand June 15, 1939 | | $1,549.11 |

## PERMANENT FUND

| | | |
|---|---|---|
| **RECEIPTS** | | |
| Balance on hand June 15, 1938 | | $1,226.97 |
| Interest on savings account | $ 19.53 | |
| Interest on mortgage certificates | 231.66 | |
| Dividends on Commonwealth Southern Pfd. | 30.00 | 281.19 |
| Total receipts | | $1,508.16 |
| **DISBURSEMENTS** | | |
| Transferred to General Fund for purchase of 6 U. S. Government Bonds at $75.00 each and 3 at $12.50 each | 487.50 | |
| Total disbursements | | 487.50 |
| Balance on hand June 15, 1939 | | $1,020.66 |
| Par value of certificates other than Government Bonds | | 5,000.00 |
| Par value 10 shares Commonwealth Southern, pfd. at $100.00 each | | 1,000.00 |
| Total | | [2]$7,020.66 |

[2]The market value of certificates during the past year has been far below par, but since there is no open market no established cash value is available. The cash value of the 10 shares of Commonwealth Southern Preferred, par value $100.00, as of June 15, 1939 was $615.00.

# REPORTS OF VICE-PRESIDENTS OF DIVISIONS

## REPORT OF THE DIVISION OF FISH CULTURE

H. H. MacKay

A review of the progress made in the sphere of fish culture during the past decade discloses that hearsay and haphazard methods are being replaced by those based on exact knowledge and rational procedure. It is true that many matters need clarifying and that more general agreement is required regarding certain practices concerning which widely divergent views are held. Generally speaking, however, out of a maze of uncertainty, a more concrete idea of the aims and purposes of this important subject is gradually taking shape.

In its wider and truer meaning fish culture is closely linked to aquatic biology, physics, commercial fishing and angling, and it is difficult to give a comprehensive definition of the term. However, for all practical purposes it may be said that a progressive fish-culturist is one who measures his success in terms of the good fishing that results from his labours.

Within the compass of a report of this nature, it is impossible to deal satisfactorily with all the recent developments in the various divisions of fish culture. Therefore, the discussion will be confined to two major problems, namely, fish food and fish diseases. A great deal has been said and written on these important subjects, and the excellent bulletin, "Care and Diseases of Trout," by Dr. H. S. Davis is widely known. It is used extensively as a guide in many, if not all, of the hatcheries of the continent and has assisted fish-culturists in solving many vexing problems.

For the purpose of surveying the general situation, state, provincial and federal departments were canvassed to submit a brief account of the contributions made during the past five years in regard to progressive developments in fish culture as follows:

1. (a) Actual reduction in the cost of feeding artificially reared fish by the use of substitutes for beef liver, either entirely or partially, and on a satisfactory nutritional basis.
   (b) What food items added to the diet of artificially reared fish were found unsatisfactory.
2. The control of parasites and diseases of artificially reared fish.

This opportunity is taken of thanking those who responded so kindly and generously to this questionnaire.

Because beef liver was found to be a satisfactory food, conducive to the growth of young trout, it was and still continues to be used widely in trout hatcheries and rearing stations throughout the continent. The price of this commodity has increased considerably during the past few years, resulting in a large increase in the cost of rearing trout. As a result of this increase, extensive and intensive experiments have been conducted to find a nutritional equivalent for beef liver or even a partial substitute. At first, experimentation for the most part was of a laboratory nature, but more recently experiments have been conducted under actual hatchery conditions.

The application of scientific facts is slow since many fish-culturists are unwilling to discard old methods for new ones. Generally speaking, however, certain findings have been demonstrated so conclusively that they are commencing to have a profound effect on feeding methods everywhere, although, there is still probably no question on which fish-culturists differ more widely than in regard to what constitutes the most satisfactory food for trout.

The criteria of a successful diet are low cost, low mortality, and satisfactory growth. In evaluating diets, we should eliminate those that show no promise of

rearing fish at low cost, since a production basis at low cost is essential, and select the remainder on the basis of low mortality and satisfactory growth.

Now, nearly every rearing station may be considered to have its own set of conditions, and its own problems in regard to the factors involved, so that any particular study may apply to local conditions, and only indirectly to conditions elsewhere. Keeping these facts in mind the results of the survey may be summed up as follows:

1. In the fry and early fingerling stages of trout, a diet of fresh meats is best. Up to this time the cost of food may be a relatively unimportant factor, but when the 2-inch stage is reached a diet must be found that will produce large, healthy fish at low cost.
2. Trout can be reared on a straight meat diet, but there is considerable difference of opinion as to which meat has given the best results. Probably no meat has given better results with young fingerlings than beef liver and it would likely be used more extensively if it were not for the cost.
3. Generally speaking, a mixed diet of meats is more satisfactory than one meat used alone. Ontario and Minnesota have experienced good results in feeding such a combination as liver, beef hearts and beef melts. If we examine the diet composition sheets used by New York State, we shall find that a mixture of meats was used satisfactorily. It is recommended that those who are interested in this field obtain copies of these sheets for ready reference.

   There are exceptions to all rules, however, and we are told that in the State of Tennessee beef hearts are fed exclusively with good results.

   J. H. Wales and Myron Moore, California Division of Fish and Game, fed beef hearts, beef liver and beef lungs as straight diets to three groups of rainbow fingerlings and found very little difference in health and growth.

   In the State of Massachusetts pork liver has been substituted for beef liver with satisfactory results in feeding brook, brown and rainbow trout.
4. The New York State nutritional laboratories have shown that the cost of feeding trout has been reduced 50 per cent by the use of substitutes. Fresh meats plus cottonseed meal, fish meal, buckeye shiners, middlings, skim milk and salt have been used successfully (see diet composition sheets for State of New York, Conservation Department).

   In Ontario such combinations as 60 per cent beef liver plus 40 per cent "Fishotein" and also 60 per cent beef liver and 40 per cent menhaden meal were shown to be economically superior and nutritionally equal to beef liver used alone. Sixty per cent beef liver plus 40 per cent "Silver Fur Food" were found to be superior in every respect to beef liver alone.

   Such combinations as:

| | *Percentage* | |
|---|---|---|
| Beef liver | 75 | 50 |
| Alewives | 25 | 50 |

have shown excellent possibilities. In addition to feeding fresh raw fish, several tons of alewives were processed and this meal when mixed with fresh beef liver gave good results.

The following combinations could not be considered since after feeding for a period of 132 days the fish began to die from an intestinal disorder which could only be blamed on the diet:

| | | *Percentage* | | |
|---|---|---|---|---|
| Beef liver | 75 | 40 | 50 | 50 |
| Soybean meal | 25 | 10 | ---- | 10 |
| Pig meal | ---- | 50 | 50 | 40 |

Rainbow trout made satisfactory progress on a diet of 50 per cent beef liver, 25 per cent pilchard meal and 25 per cent ling. Sucker was substituted for ling later in the experiment.

In connection with Ontario experiments it should be stated that fingerlings handled in large tanks gave much better results than those handled in hatchery troughs or in smaller galvanized iron troughs.

5. James T. Wilkinson, Department of Conservation, Lansing, Michigan, found as a result of controlled experiments using sheep liver as a control that the satisfactory minimal proportion of liver was 25 per cent by weight in a mixture of sheep liver with such substances as whitefish meal, cottonseed meal, skim milk powder and oatmeal.

It was shown also that the mortality record of rainbow trout indicated that only those diets containing liver should be considered.

After eliminating diets on the basis of cost or high mortality, the following diets remained:

| | *Percentage Composition* | | |
|---|---|---|---|
| *Diet* | *No. 4* | *No. 17* | *No. 18* |
| Sheep liver | 50.0 | 50.0 | 30 |
| Whitefish meal | 16.7 | 13.3 | 20 |
| Cottonseed meal | 16.7 | 13.3 | 20 |
| Skim milk powder | 16.7 | 13.3 | 20 |
| Oatmeal | ..... | 10.0 | 10 |

With respect to the growth records of the rainbow trout No. 4 and No. 17 ranked second and third respectively.

Now, if the chief aim is to grow larger fish, Diets 4 and 17 should be chosen. Diet 17 had the lowest mortality record, ranked second in growth and fourth in cost (only slightly more expensive than Diet 4). Diet 18 enabled the fish to be reared at a cost about 15 per cent less than Diets 4 and 17; the mortality record was low and the fish appeared to be in good condition.

For brown trout, Diets 4 and 17 were recommended from the standpoint of low mortality and good growth, and Diet 18 from the standpoint of low mortality and low cost.

Trout can be reared more cheaply, and with a mortality record about as low, on Diets 4, 6, 17 and 18 than on a straight sheep-liver diet. In general, trout fed on sheep liver showed excellent growth and low mortality but the cost was about double.

Results of the rainbow and brown trout experiments were comparable to those with the brook trout in that Diet 18 again provided low-cost fish, this time in third place. Diet 18 was also associated with the lowest mortality record, and was outstanding when cost was the chief consideration. Diets 4 and 17 were best when low mortality, good growth, and relatively low cost were desired.

Diets containing pig melts were found to be the least desirable because of the heavy mortality.

6. It would appear that there is no satisfactory method of feeding high meal concentrations to fingerlings smaller than twenty-five per ounce. Fingerlings larger than twenty-five per ounce can be fed straight meal pellets twice a day and meat once a day. Unless some method can be found whereby liver and meals can be combined without serious water pollution it will be impractical to feed small fingerlings more than 25 per cent meal, according to J. H. Wales and Myron Moore, California Division of Fish and Game, 1937.

Salmon egg meal and dry skim milk if properly used are excellent substitutes. They can be combined with a relatively small percentage of liver to give rapid growth at low cost, according to J. H. Wales and R. C. Lewis, California Division of Fish and Game, 1935.

The South Dakota Department of Fish and Game and Alberta workers have had unsatisfactory results with salmon egg meal.

Dehydrated beef meal has been found to be a valuable trout food, com-

paring favorably with salmon egg meal and dry skim milk, according to J. H. Wales and Richard Bliss, California Division of Fish and Game.

Clam meal and alfalfa meal may be used advantageously.

The West Virginia Conservation Commission hatcheries report that seal meal was found to be satisfactory at one hatchery but toxic at another.

J. H. Wales and Myron Moore, California Division of Fish and Game, fed a pond of approximately 3,000 yearling brook trout a commercial dog food for a period of six months. The dry meal was fed alone but it is probable that this fish also obtained some aquatic and terrestrial organisms. The dry food supposedly contained all the minerals and vitamins necessary for the health and growth of dogs. In five months the fish became seriously anaemic and by the end of six months losses were so heavy that the diet had to be changed. In about two weeks with a feeding of 100 per cent beef liver mortality ceased.

7. Charles Hayford, Hackettstown, New Jersey, recommends the following diets:

| *First day* | *Second day* |
|---|---|
| Sheep plucks | Salt water herring |
| Dried fish meal | |
| Alfalfa meal | |
| Cod liver oil | |
| Dried blood meal | |

Canned fish is also used.

He did not have satisfactory results with dried buttermilk.

8. In feeding fingerlings and yearling stock, the Massachusetts Division of Fish and Game uses a pasteurized by-product of the sardine industry plus pork melts, plus dried foods. Fish are used in varying proportions according to the age of the fish fed, temperatures, and factors peculiar to the water supply.

The Wisconsin Conservation Department is carrying out a carp removal programme on a large scale. In order to make this particular activity self-supporting, the large carp are marketed and the small ones canned. The Department considers canned carp a satisfactory diet for trout, providing fresh meat is added periodically for the purpose of supplying "Factor H." The canned carp diet was fed under low and constant temperatures. It might be mentioned here that Wisconsin workers are also studying the amount of roughage, proteins and carbohydrates that are necessary for the satisfactory nutrition of trout.

Beef liver plus one-third to one-half "Balto" canned fish food, or 50 per cent sheep liver plus 50 per cent "Balto" canned fish food may be fed satisfactorily. The South Dakota Department of Fish and Game reports considerable savings by feeding the "Balto" product. West Virginia reports that the hatcheries were able to reduce the cost of feeding 50 per cent by adding "Balto" to beef liver.

W. W. Aitken of the Iowa State Conservation Department has shown that fingerlings can be fed on a mixed diet of beef hearts and canned fish, namely, cooked carp and buffalo at a saving of 25 per cent and on canned fish alone, without serious impairment of the quality of the fingerlings. Negative results were obtained with smaller fish.

The importance of proper feeding is much underrated, and unless those who are responsible for this important work are most painstaking in regard to the actual method employed in feeding, and in the preparation of the food, terrific waste will result. If food is carelessly administered by adding too much water most of the food will be washed down the drain. In the same connection the palatability of the food must be observed carefully. It appears that it is better to feed all the fish will take. Underfed fish grow more slowly, and any adverse conditions inevitably lead to disease under such circumstances.

*Warm-water Fishes*—In most cases warm-water fishes are reared in specially

prepared and fertilized nursery ponds. Minnow ponds for the cultivation of golden shiners, blackhead minnows and other suitable forage fishes are often employed.

Dr. T. H. Langlois has succeeded in revolutionizing the method of rearing bass by using narrow ponds and feeding ground carp. When the fish-eating stage is reached, conditions in the ponds are such that there is very little, if any, vegetation.

South Carolina reports success in feeding warm-water fishes with beef hearts and 50 per cent wheat shorts by volume. The shorts absorb the superfluous blood, giving the meat particles additional buoyancy, and thus enabling the fish to consume the food before it settles to the bottom.

Alabama reports the use of beef hearts and stale bread. There were instances where beef liver and hearts did not produce results comparable with the natural foods produced in hatchery ponds.

*Disease Control*—In disease control three fundamental factors must be kept in mind; these may be set forth more or less categorically as follows:

1. Prevention of overcrowded conditions.
2. Sanitation.
3. Proper feeding methods.

If proper attention is not paid to these requirements, high mortality will result. When all is said and done, prevention rather than cure should be the chief consideration.

Acriflavine is a valuable disinfectant. In Ontario we have used it successfully for treating bacterial infection of lake trout eggs.

J. H. Wales and R. C. Lewis of the California Division of Fish and Game have shown that unless care is taken water may become polluted with fine particles of dry skim milk and salmon egg meal. These fine particles are harmful to the gills of very young trout, especially rainbows. It is suggested that the young trout be started on 100 per cent heart, gradually changing to liver and meal later, since heart can not be combined satisfactorily with dry meals.

J. H. Wales and Donald Evins, California Division of Fish and Game, report that there seems to be little doubt that certain kinds of organic material and living organisms such as diatoms, other small algal forms, bacteria, and protozoa in water supplies lead to irritation of the gills. This disease which is not due to a specific organism is called "Sestonosis," "seston" meaning a mixture of living and non-living bodies which float in the water and "osis" indicating disease. Certain strains of trout are more resistant than others. This difference might have been brought about by natural selection in the native waters of particular strains of trout.

The use of calomel in treating fish suffering from octomitus is of very great value. This treatment was originally suggested by C. M. McCay and A. V. Tunison.

Intensive researches are being conducted to find a cure for furunculosis. Wisconsin workers have experimented with injections of sera, antigens, etc. The drug, sulphanilamide, and also malachite green, gentian violet and acriflavine have been tried. It is reported that some of these experiments have supplied encouraging but not conclusive results. J. H. Wales and W. Berrian, California Division of Fish and Game, have suggested that fin rot may act as one predisposing factor in furunculosis. This suggests the importance of correcting fin rot before it becomes advanced or widespread.

Heavy fertilization of ponds leads to heavy infestations of fish with flukes.

"H.T.H." is used extensively for sterilizing ponds and hatchery equipment. Certain Ontario hatchery officers have used "H.T.H." as a treatment for gill disease and record success, but we are frowning upon its more general use for this purpose until its success is clearly demonstrated.

Wisconsin reports a method of collecting bass spawn by the usual stripping method. Just how practical this is as compared with the natural spawning method remains to be proven.

During the past winter Wisconsin fish-culturists, biologists and endocrinologists developed a method of injecting pituitary hormone into fish in order to

advance or hasten their spawning activity. It is reported that this was put into practice during the spring of 1939 with considerable success, in connection with the spawning of maskinonge.

In conclusion, it should be mentioned that the use of white enamelled troughs in hatcheries is becoming more general due to the ease with which disease and debris may be observed in troughs of this kind.

---

## REPORT OF THE DIVISION OF AQUATIC BIOLOGY AND PHYSICS

L. R. Donaldson

I shall not attempt to read a long dissertation on the various activities in this most extensive field. I will just comment, in a sentence or two, on the highlights that appeal to me as being outstanding.

Work in the fields of aquatic biology and physics during the past year has been characterized by its practical trends and its application to the problems of practical importance. Problems of fish management have occupied the "lion's share" of our attention.

The attitude of the workers in this field is encouraging, inasmuch as it has assumed a rather critical trend and a questioning tendency. The procedures that we have accepted as standard are being evaluated more and more with emphasis on the practical side and its application to fisheries in general. Some of the other basic fields of fisheries research, however, have not quite kept pace. I refer especially to the fields of fish physiology as applied particularly to our commercial and sport fishes. Research institutions with adequate equipment and universities and colleges that have adequate staffs and equipment might well emphasize these phases of fisheries research to augment our knowledge and its added application to the more practical fields.

---

## REPORT OF THE DIVISION OF COMMERCIAL FISHING

Hilary J. Deason

In the beginning there was an abundance of fish, and fishermen were few. As the number of fishermen increased and the methods of fishing improved the total quantity of fish produced also increased. But soon came a time when the increases in number of fishermen, number of boats, and quantity of fishing gear did not result in a commensurate increase in the catch. Thus depletion entered the picture, and the need arose for scientific investigations to determine the causes of the decline in the yield of the fisheries. Conservation of existing resources and attempts to rehabilitate the stocks were almost invariably recommended upon the completion of fisheries studies.

The first large program of fisheries research was begun in Denmark and Norway about 1860. Fisheries investigations assumed international scope with the organization of the International Council (Conseil Permanent International pour l'Exploration de la Mer) in about 1900. Since that time the International Council has been concerned primarily with the conservation and rehabilitation of the fisheries of the North Sea. Many of the fundamental methods, the different kinds of apparatus, and the biological principles that are now associated with the large commercial fisheries research programs had their origin in the work of the Danish and Norwegian investigations and of the International Council. These same fundamental methods and principles have recently been applied to investigations of game fishes. The much earlier establishment of the

commercial fishing industry and consequently the much more prior decimation of the stocks of some of the principal commercial species led to a serious need for scientific investigations of the commercial fisheries long before angling had become so popular that the perpetuation of the sport was threatened.

It is believed that a discussion of some of the various commercial fisheries investigations that are in progress in various parts of North America at the present time will provide a worthwhile departure from the economic and industrial report usually presented by the vice-president of the Division of Commercial Fishing. Some time ago letters were addressed to a large number of fisheries workers in North America requesting information concerning their current research activities. The factual information contained in this report has been gleaned from the many and generous responses to those letters.[1]

Fisheries research is aimed at the general objective of conservation, which may be defined as saving what we have. The many attempts at conservation of commercial species of fishes have, in the main, been unsuccessful and are best described by a perversion of the term, conservation, to a form frequently met as a typographical error, "conversation." Conservation, in the sense of saving what we have, is an idealistic procedure and usually takes some form of rehabilitation. To continue the definitions: rehabilitation is an attempt to regain what has been lost, or, in paraphrase, "locking the barn after the horse has been stolen." Rehabilitation is best effected through management; management in this sense meaning the spending of the "net earnings or proceeds" and not the ''capital stock, machinery, and fixtures.'' Utilization is making use of what we formerly did not harvest, or threw in the garbage can.

Not until emergencies arise and sentiment is aroused to fever heat are finances and personnel made available for the securing of factual information concerning the life-histories, natural abundance, distribution, and other details that serve to facilitate a sound regulation of the fisheries. The International Council was born of the seriously impaired North Sea fisheries. The threatened collapse of the Alaska salmon-packing industry led to the establishment of a continuous research program and the institution of a system of discretionary management and regulation. The very serious decline in the catches of the halibut and the inability of legislative agencies to enact constructive regulations led to the signing of an international treaty providing for scientific investigations by an international commission. The treaty was later amended to grant the commission regulatory powers. The collapse of the Lake Erie cisco fishery in 1925 led to the establishment two years later of a continuous fisheries research program on the Great Lakes by the U. S. Bureau of Fisheries. Previous to that time declines in abundance of important Great Lakes species had been noted, and conservation officials and commercial fishermen had been warned by the individuals who were detailed to make casual surveys, but very little constructive action resulted. The threatened extinction of the abalone in California led to researches that were instrumental in the enactment of very stringent legislation. If the abalone fishery had been judiciously exploited from the beginning, we would not now have the unfortunate condition where the mention of the word, abalone, in localities apart from the Pacific Coast is met with the query, "Is it fruit, vegetable, or meat?"

The necessity for rehabilitation almost invariably results either from unwise exploitation and unwarranted expansion of fishing activities, or from the destruction of spawning grounds and nursery areas by industrial or other pollution or by large-scale water impoundment or irrigation projects. Examples

---

[1]Sincere thanks are offered for the information supplied by Mr. Elmer Higgins, Mr. W. C. Herrington, Dr. Frederick A. Davidson, and Mr. Robert A. Nesbit, U. S. Bureau of Fisheries; Dr. W. F. Thompson and Dr. R. E. Foerster, International Pacific Salmon Fisheries Commission; Dr. Wilbert A. Clemens, Fisheries Research Board of Canada; Dr. Willis H. Rich, Fish Commission of Oregon; Dr. Frances N. Clark, Calfornia State Fisheries Laboratory; Dr. Emmeline Moore, New York Conservation Department; Dr. T. H. Langlois, Ohio Division of Conservation; Dr. Edward Schneberger, Wisconsin Conservation Department; and Dr. Lewis Radcliffe, Oyster Institute of North America.

of depletion and of the research work in progress that is designed to halt the decline and bring about rehabilitation will be mentioned according to regions and individual species.

## Pacific Coast

*Halibut*—The investigations of the International Halibut Commission disclosed that the annual catch of halibut was being maintained by a constant increase of fishing intensity and the continuous extension of operations to include new grounds. Through an analysis of the catch data in terms of yield per unit of fishing effort, by coordinating previous researches, and by continuing investigations of all phases of the natural history and distribution of the species, data were obtained that enabled the Commission to attempt to restore the abundance of halibut through a limitation of catch. A considerable strengthening of the population and a larger catch per unit of effort have resulted. The halibut fishery has now become largely seasonal, for fishermen produce their allotted quota in a few months, and at a time of the year when damage to spawning adults is least likely to occur. Expansion of the halibut industry has been discouraged, and the maintenance of an adequate population to support the limited fishery has been assured.

*Pacific Salmon*—The several species of Pacific salmon that support fisheries from California to Alaska present many complex problems and the researches in progress are correspondingly numerous and diversified. Studies of the pink salmon are being made by the U. S. Bureau of Fisheries, by the Fisheries Research Board of Canada, and by state and provincial agencies. The work includes studies of fluctuations in natural abundance, and the time of appearance of runs. Migration is being investigated through tagging experiments, and oceanographic observations are yielding physico-chemical data for correlation with the migration data. The Bureau of Fisheries' studies of the coho salmon concern the life history, migration, and observations on spawning grounds. The red salmon of Bristol Bay recently has been subjected to such extensive offshore exploitation that considerable concern over the future of the fisheries has been voiced. The Bureau of Fisheries received special appropriations for large-scale investigations that include an evaluation of the spawning populations, analyses of the runs, and the determination of causes of the mortality of eggs and young fish. Marine studies of red salmon are principally oceanographic and migrational. Fecundity is being studied by means of ovarian counts. The recently established International Pacific Salmon Fisheries Commission has taken over the investigation of the Fraser River sockeye, which has now been reduced to about one-fourth of its former abundance. Present work includes research on migration times and routes, counts of spawning escapement, and racial and natural history studies of sockeyes in each nursery area. Construction projects and irrigation diversions have rendered many rivers and portions of river systems unsuitable for salmon and have made many spawning grounds inaccessible. The Bureau of Fisheries has an extensive stream survey of the Columbia River System in progress for the purpose of classifying areas that may be repopulated and made accessible to the salmon. The survey has included studies of the spawning redds of several species of salmon. The marking of chinooks will determine the rate and route of migration, the distribution in the river and the mortality during migration. A similar study by the Fish Commission of Oregon has been concerned with evaluating the adverse effects of the Bonneville and Grand Coulee dams on the salmon resources. The Bureau of Reclamation also is cooperating in that investigation. Construction projects, as well as overfishing, have reduced the salmon runs in certain California rivers. The California Department of Fish and Game is attempting to evaluate present salmon runs in each stream, to determine the relationship of present and proposed structures to spawning areas, and to estimate the spawning escapement with a view to establishing a maximum sustained yield for each area. Studies of predators and predator-

control measures are also being considered in various salmon waters, principally by investigators of the Fisheries Research Board of Canada, who have determined that the low percentage of survival of naturally hatched fry has a definite relationship to predators.

*Pilchard*—The pilchard, or California sardine, is the most important single species in North America from the standpoint of total catch. There has been a tremendous increase in annual production during the last decade, which is directly traceable to the expansion of the fishing fleet and the multiplication of floating reduction plants that anchor offshore, outside of the jurisdiction of state conservation officials, and thus exempt themselves from regulations that have been enacted for the preservation of the species, and from payment of the tonnage tax. Studies supported by the conservation departments of the three Pacific Coast states, especially by California, and by the Province of British Columbia, had resulted in the accumulation of a considerable fund of life-history, ecological and statistical information. In 1937, the U. S. Bureau of Fisheries entered the field, not solely as an independent agency, but as a coordinator of the various research activities, and also to carry on new lines of investigation of greater than intrastate scope. The primary objective of all the pilchard research is to determine whether or not natural criteria can be discovered that will enable the fisheries scientists to forecast the available catch each year and also determine the proper limit on production, so that irreparable depletion of the population will not occur.

*Pacific herring*—Investigations of the Pacific herring are being conducted by the Fisheries Research Board of Canada and by the U. S. Bureau of Fisheries. The Bureau has been concerned with the tremendous decrease in the Alaska herring fishery that took place subsequent to 1927. One factor in the decline has appeared to be the complete absence of three consecutive year classes, 1932, 1933, and 1934, in the population of the major fishing area. These deficiencies, together with a too intensive fishery, reduced the species to a dangerously low level of abundance. Tagging experiments demonstrated the existence of localized populations, and a repeated use of certain spawning grounds by the same individuals. Herring fisheries of northern Alaska areas are less intensively prosecuted than the southeastern fisheries, and are in better condition. Canadian researches consisted principally of a tagging program and the sampling of the commercial catches. Local populations of herring have been found to occur in British Columbia waters.

These important lines of investigation are by no means inclusive of all the work that is being done on the Pacific Coast. Investigations are under way also on the mackerel, tuna, flatfishes, oysters, and many other species of lesser importance.

### Atlantic Coast

*Shad*—The yield of the shad fishery has been reduced to about one-fourth of its former annual total, and actually the depletion of the stocks has been much greater than the production statistics alone would indicate, because present-day catches are obtained through a much greater expenditure of fishing effort than was necessary for the production of the former maximum annual catches. Pollution, as well as overfishing, has played a part in the decline. Studies of spawning escapement and of age composition of the stocks are being conducted by the U. S. Bureau of Fisheries, in order to evaluate the magnitude of the different runs. Maryland is cooperating in the studies by investigating some of the more local shad populations and fisheries. Recoveries have been effected in the Hudson and Connecticut Rivers by the enforcement of stringent regulations. However, divided control of the fishery in other rivers, differences in the kind of gear used in various areas, and mixed fisheries in certain regions, where shad is only one of a number of species taken, make the formulation of adequate preservation measures a complicated task. Unified control by an interstate agency may ultimately prove necessary.

*Striped bass*—It has been recognized that the striped bass population is incapable of supporting yields comparable to those of the cod, haddock, or mackerel. The conservation of striped bass is further complicated by its value as a game fish. Researches of the Maryland Conservation Department demonstrated the important role of dominant year classes in the population, and proved that dominant year classes do not necessarily result from an unusual abundance of spawning adults on the grounds. Tagging experiments conducted by the Maryland Conservation Department and the Bureau of Fisheries resulted in the conclusion that overfishing was the principal cause of the decline in abundance. An increase of the legal size limit has been recommended in order to permit more adults to attain sexual maturity and thus provide for a larger spawning reserve.

*Haddock*—The catch of haddock has exhibited a significant decrease during the past three years and at the same time the percentage of small haddock or scrod in the catches has tended to increase. The capture and sale of larger quantities of small haddock is considered poor economy, inasmuch as the fish are growing very rapidly at the time of capture and if allowed to remain in the water for an additional period would not only yield a greater poundage to the fishermen, but would bring a better price per pound. The catches per unit of effort, according to Bureau of Fisheries data, have remained at a significantly low level since 1931 as compared with the catches of earlier years. Researches are being conducted to determine the causes of fluctuations in abundance, to analyze the age composition of the catches and of the populations, and to study migrations.

*Mackerel*—Records compiled by the Bureau of Fisheries show that the mackerel catches have exhibited tremendous fluctuations, but that the total annual landings of the earlier days of the fishery (prior to 1885) were about twice as great as those of recent years. In 1937 the mackerel fishery was almost a financial failure. Long and diversified researches have proved that the commercial catch of a particular season is made up of only a very small number of year classes, and in some years consists almost entirely of a single year class. A study of the relationship between hydrographic conditions and the catches has demonstrated that there is a possible relationship between temperature and the success or failure of the fishery. Studies of factors such as migration, the natural mortality of certain year classes, and the selective effects of various types of fishing gear are included in the investigational program.

*Flounder*—At least five species of flounders are involved in the fisheries, and each has its own characteristic life history and habitat. The present Bureau of Fisheries investigations involve, in addition to life-history studies, measurement of the abundance of the stocks in an effort to ascertain the causes of the declines in the annual landings that took place from 1930 to 1935. The flounder fishery studies are complicated by the fact that the sport fisheries during recent years are believed to produce as great an annual yield of one or more species as the commercial operations. It is evident that commercial production is being maintained largely by augmenting the fishing intensity. During 1938 the New York Conservation Department and the Bureau of Fisheries made a cooperative survey off Long Island, and many pertinent data on both sport and commercial fisheries were accumulated. The cooperation of the State of Maine is promised, and that of other states expected, during the 1939 season, in the collection of needed statistical records and other data. New York and Connecticut joined the Bureau in a tagging program in 1938. The recoveries reported so far have yielded important data on migration.

Investigations of additional species could be mentioned, but the preceding remarks illustrate the general trend of fisheries research on the Atlantic Coast and show that in that area unwise exploitation and increased fishing intensity have given rise to the most troublesome problems of conservation.

### Great Lakes

The critical depletion of the more valuable commercial species continues to be the major problem of the Great Lakes fisheries. The extent of this depletion is apparent from comparisons of the present-day catches of certain species with those of former years. The depletion in Lake Michigan is fairly typical of the other lakes; if normal production is assigned an index value of 100, then the productions of the more important species are as follows: wall-eyed pike, 62; lake herring, 59; lake trout, 58; whitefish, 58; yellow perch, 43. The famous Lake Superior whitefish is being produced in quantities that are 90 per cent below normal. The total catch of all species in Lake Ontario is 80 per cent below normal. In Lake Erie the production of nearly all important commercial species is on the decline. The downward trend in the production and the natural abundance of important Great Lakes species has not reached its limit, except, of course, for the sturgeon, the Lake Ontario bloater, the blackfin of Lakes Michigan and Huron, and the cisco of Lake Erie, which have all been reduced to a position of commercial insignificance. Present conditions with reference to most species represent only a stage in the process of depletion that will certainly lead to the complete ruin of the fishery unless immediate and drastic measures are taken to halt present abuses. One by one studies of the life histories of the Great Lakes fishes are being completed by the U. S. Bureau of Fisheries. Gear-selectivity studies have been completed on three lakes. A recently inaugurated research program in Ohio should be of material assistance in building up a stock of factual information that will facilitate sound regulation. Wisconsin is investigating some minor Great Lakes problems. The collection and analysis of daily catch statistics, that include information on the quantity and kind of gear and the length of time it was fished, have now reached a commendable state of efficiency in Michigan, Wisconsin, and Ohio. It is hoped that the remaining Great Lakes states will institute similar statistical procedures without further delay.

### Management of Commercial Fisheries

Sound regulation is synonymous with good management. The first essential to regulation is accurate knowledge. There is now available a vast store of data concerning most of the major commercial fisheries, but those data are of no practical value unless they form the basis of adequate regulations. The recommendations made from time to time by investigating bodies occasionally have resulted in constructive legislation. That legislation, however, usually has been inadequate, and more often than not has represented a considerable departure from the original recommendations. Fully adequate regulations frequently are so drastic that a near-sighted commercial fishing industry will spend large sums of money to combat legislation that would work toward its ultimate betterment. Legislatures frequently are persuaded to modify existing laws so that they will conform with those of the state that has the least stringent code. As an example, upon the basis of a three-year survey it was recommended that gill nets fished for chubs in Lake Michigan should be 2¾ inches stretched measure. The State of Wisconsin agreed to alter its regulation to meet the recommendation. Almost simultaneously, however, the Michigan legislature was persuaded to decrease its existing mesh specifications from 2¾ to 2⅝ inches. Numerous similar illustrations might be given. Control of the fisheries through legislation formulated by ill-informed and disinterested legislators, who try to satisfy the clamorings of selfish and financially powerful constituents, frequently is eminently unsatisfactory.

The effectiveness of any regulation depends solely upon its enforcement. The failure to enforce commercial fishing laws constitutes yet another impediment to a sane management program. Non-enforcement of a gill-net mesh regulation and failure to enforce size limits on two species for single seasons in Ohio produced increases in the annual catches. A prodigious quantity of

immature and commercially inferior fish was destroyed. Those increases, however, were followed by a disproportionately large drop in the annual yield as soon as enforcement was resumed. The supposed gain actually was a loss. Another deterrent to sound conservation is the ease with which an organized group of fishermen may obtain injunctions from local courts that restrain the state officials from enforcing any laws that the fishermen consider an immediate and material detriment to their operations.

The differences in the regulations of two or more adjacent or neighboring states that govern the fisheries of the same waters also result in dissatisfaction and give rise to irregularities in enforcement. Differences in mesh regulations and in size limits applied to the same fisheries actually encourage violations. The possibility of the enactment and enforcement of uniform codes by different states is extremely slight, because of previously mentioned political interference, lobbying, and enforcement irregularities that inevitably are associated with a system of divided control.

The commercial fisheries deserve sound, intelligent management, and those fisheries that are prosecuted by the fishermen of more than one state or nation must be placed under the jurisdiction of competent boards or commissions which collectively represent persons interested and informed concerning both the practical side of the fishing industry and the biology of the fishes that are produced. The success of the International Halibut Commission is an example of what can be accomplished by efficient management based upon a continually enlarging fund of scientific information. It must be realized that very little, if any, physical expansion can be permitted if the commercial fisheries are to be perpetuated. Retrenchment in many fisheries is extremely desirable. Controlled production, the inevitable result of sound management, will not only conserve the stock but will go far toward relieving unfavorable market conditions and eliminating unsavory wholesaling methods, that so frequently are disadvantageous to those who do the most work and yet reap the smallest profit—the men in the boats.

Problems that accompany the installation of water-power and irrigation constructions made without the consideration of adequate plans to preserve the fish fauna in the areas affected constitute another aspect of fisheries management that has received too little attention in the past. Fortunately, public sentiment has been aroused through several outstanding examples of neglect and disregard of the possible effects of construction projects, with the result that fisheries experts have been consulted with respect to some of the more recent developments. Frequently the authorities responsible for the developments have been very considerate of recommendations made by fisheries biologists.

## The Problem of Utilization

Utilization is a much neglected phase of conservation that must receive a constantly greater amount of consideration if the greatest possible value is to accrue from our fisheries resources. A most important phase is the extension of fishing activities to new grounds so that the fishing intensity in heavily fished areas and the attendant dangers of irreparable depletion may be eliminated. Utilization must also attempt to find a market for species not ordinarily produced, so that all items of the crop, and not merely the choicest articles, are utilized. All too frequently are the possibilities for marketing new species wholly neglected until the choicer varieties have been seriously depleted. When that depletion has become a fact the fisherman, in order to exist, must produce and attempt to market the formerly neglected species.

Technological studies have assisted in the utilization of cannery wastes and inferior products in the manufacture of by-products, but the field is still wide open and numerous advances in this phase of conservation are possible. Although tremendous advances have been made in canning, freezing, and packaging fisheries products, a mere beginning has been made, and the marketing problem itself has received little or no attention. With modern methods of transportation and refrigerated rolling stock at the disposal of producers and wholesalers, there is no

reason why fresh fish can not be transported to almost any part of the United States and Canada, and reach the consumer in first-class condition. Many of us, however, have visited fresh fish markets in inland communities and found that recently received shipments of so-called fresh fish were fit for nothing but mink food.

One of the most important problems of utilization concerns the necessity for a program of education in the use of fishery products. States advertise their industries, food products, scenic attractions, and tourist facilities and frequently such advertising is supported by direct legislative appropriations. The highly developed systems of merchandising and advertising now associated with other foods are not duplicated in the fresh fish business. It is hopeless to expect fish and other sea foods, in the condition in which a large share of them is marketed, to compete with attractively displayed, rigidly inspected fruits, vegetables, and meats. These latter products are presented to the public through educational and advertising methods of the highest calibre. Fish, to a great many, is synonymous with a necessary evil-smelling substitute for meat that must be consumed on occasions in accordance with certain religious tenets of some groups of people.

The present system of wholesaling results in unwarrantedly high retail prices that directly limit consumption. The wholesaler retains the lion's share of the profit, and the retailer and producer are forced to absorb all loss through spoilage and operate on a scanty margin of profit. So long as the wholesale fish business remains in its present condition and exists for the benefit of a small number of unscrupulous individuals who are deserving of the name "racketeers," the public will not be given palatable fish and the producer will not receive a fair price for his product. The producer will exploit the natural supply to the greatest possible extent, will oppose any and all sound measures for the preservation of the resources, and when apprehended for infractions will plead dire poverty and distress.

Supervision of fish markets and of the marketing systems is just as much a province of conservation officials as the regulation of the production of the fisheries. Conservation is wise utilization to the best possible advantage, and in the realization of that ideal there is no room for wilful waste and unregulated profiteering. Let us take immediate steps to free the fisherman, especially the small independent man, from the clutches of commission merchants who have him in virtual servitude. Wise utilization of the products of our fisheries will work toward better laws, less opposition to adequate and constructive regulation of the fishing enterprise, and an improvement of the social and economic status of the man who works in the boats.

## REPORT OF THE DIVISION OF PROTECTION AND LEGISLATION

WILLIAM C. ADAMS

The interest shown in affording additional protection to striped bass on the Atlantic coast is one of the outstanding developments of the past year. The U. S. Bureau of Fisheries sent out an announcement some months ago advocating that the minimum length of this fish be 16 inches from the nose to the fork of the tail. New York, at the last session of its legislature, passed a law prohibiting the possession and sale of striped bass under this minimum length. The legislation will result in increased research on this fish throughout its entire Atlantic coast range, thus laying the foundation for better management in future years.

In the broader field of the entire country the outstanding development is greater recognition of the possibilities which lie in interstate compacts or treaties for the handling of fisheries involving more than one state. In a large number of states there have been set up joint legislative committees on inter-

state agreements. The Council of State Governments, with headquarters in Chicago, is the "quarterback" assisting the states in all attempts to enter into compacts.

At the present time such a compact is under consideration by all the states along the Atlantic seaboard. The states bordering on the Great Lakes are interested in a like effort under the auspices of the Council of State Governments. The possibilities of a treaty between the Dominion of Canada and the United States are being explored in the belief that this will be the most effective method of managing the fisheries resources of all the Great Lakes.

I regret that I am not sufficiently informed to discuss matters on the Pacific coast. There will be those present who can supplement this report in that field.

---

## REPORT OF THE DIVISION OF ANGLING

C. R. Gutermuth

It is regretted that a comprehensive report on angling cannot be submitted to the Society at this time. Such a summary would comprise a lengthy list of accomplishments that resulted from the extensive fisheries program being prosecuted throughout North America. The sportsman-angler, the fellow who pays for this work, probably would not be interested in the report but he is greatly interested in the results. Our present day fisherman does not pay much attention to annual reports and he is no longer impressed with gigantic figures of "paper fish." His judgment of our work is predicated on one thing, fishing conditions, and the only results he knows are the kind that show up in his creel. So, a complete report by the Division of Angling might well reflect the success or failure of our entire fisheries program.

The average fisherman appreciates the need for scientific investigation and realizes the benefits of fish culture, but the results he so patiently awaits have in many cases been very slow in coming about and his forbearance is waning. With the passing of the last new frontier and with the opening up and depletion of the remainder of our virgin territory he is faced with reality and for the first time acknowledges that something must be done to conserve, restore, and perpetuate what is left. The increased leisure hours of recent years have added thousands of new enthusiasts to the ranks of ardent fishermen.

The newcomers, like the old-timers, are practical business men so they consider this business of fishing from a practical standpoint. They are beginning to wonder and are asking each other if, maybe, too much attention isn't being given to fish propagation at the expense of stream and lake improvement work. Many seem to think that nature would do a lot more for us if we would attempt to do things in her way instead of ours. Now—— how do they say it on the radio? "These opinions are not necessarily those of your committee but they do voice the sentiment of a great many fishermen."

Experience shows that fishermen are ready to do something besides talk. They are willing actually to work to help bring about the desired results. Of course, their assistance must be solicited and their efforts must be guided, at least for a while, but it is amazing how some of the states have expanded their operations with the support and cooperation of the local fishermen. One state, Indiana, has 434 club-operated fish hatchery ponds and nearly 400 of its 917 conservation clubs are actively engaged in stream and lake improvement work. This is bringing about the tangible results the fishermen can appreciate. No doubt some of the other states have equally startling reports.

From the viewpoint of the sportsman-angler there are three subjects that should receive attention from this organization: First, minnows and other fish foods that are used for bait; second, sport fishing in the Great Lakes; third,

the tendency of scientific workers to consider only trout to the neglect of many other important families of fishes and the much needed study of fresh-water ecology.

There is a growing complaint from fishermen everywhere that bait is getting scarce. Realizing the importance of live bait as a natural fish food, the anglers in some states have asked for laws to prevent non-resident bait dealers from coming into their state and seining the streams. If you have watched the trend of the various state legislatures you have observed that they are placing more and more restrictions on bait dealers and on the seinings done by the fishermen themselves. In a few states, for example, bait dealers are now under permit and you can find numerous streams, in which trout have been stocked, that may not be seined at all. Occasionally bait dealers ask for information on how to raise minnows and these people frequently remark that the end of promiscuous seining of streams is near at hand and that they wish to begin to raise their own bait. So, it is evident that the public attitude is changing and that in a short time the state departments will be obliged and must be able to tell the bait dealers and the fishermen what minnows can be most easily raised and how, what species have the qualities that make them good bait, and what species other than minnows can be produced in ponds to be sold as bait.

Investigation may disclose that one or more species of suckers can be produced in ponds. It is likely that crayfish could be produced easily and so managed that they will grow rapidly and that soft-shelled crayfish will be constantly on hand for sale to fishermen. It may be that bait dealers can learn to produce dobson-fly larvae—the much sought hellgrammite. Perhaps there are other forms not now considered that will come into use. There is a possibility that from the commercial bait business we will learn more about how to improve fish foods in our lakes and streams. At any rate, here is a whole field open for investigation and experiment, one that should and will receive a great deal of attention in the early future.

If the demands on our fisheries resources continue to increase it is going to be necessary to provide an enormous amount of additional fishing territory and many anglers are looking to the Great Lakes. Sport fishing in the Great Lakes is not altogether in the future. For many years anglers have fished from the piers for perch and sheepshead and occasionally they take cruises along the shoreline of Lake Michigan or Lake Superior in quest of lake trout. Recently the State of Michigan set aside certain bays in Lake Michigan for sport fishing by prohibiting commercial fishing, and a similar action was taken on Lake Superior. Angling is becoming a recognized sport in portions of these large bodies of water, and, no doubt, in this increased sport fishing we may find a new support for conserving and managing the fish of the Great Lakes. If the sportsmen add their influence to that of the scientists now engaged in the studies of Great Lakes fisheries, and if the commercial fishermen can be brought into cooperation with the anglers, we stand a good chance of working out a program for the preservation of our Great Lakes fisheries.

Should this happen—and it looks as if the tendency is in that direction—then we may face the problem of coordinating the efforts and of balancing the interests of both the commercial men and the sportsmen. This is not always an easy task but it can be done.

In this connection it might be well to review some generalizations. If you will recall, it was not the lumbermen who saved the forests, although they had the greatest interest at stake. The sportsmen, fishermen, and hunters brought about that conservation. It was not the effort of those who fished our inland streams and lakes commercially that saved our fish life; again it was the activity of the sportsmen. Look over the entire field of conservation and you will note that in every case it was not the people who made a living from wildlife who saved that wildlife but it was those who enjoyed it—the hunter, the angler, the bait fisherman, and many other kinds of outdoorsmen and nature-lovers. It is not the lumbermen who are now making demands that

wooded wildernesses be saved for posterity, and it is going to be up to the sportsmen and nature-lovers again to curtail the road building into the bits of the primeval that are left. And I might add this: When the highway comes in, the wilderness goes out. Those who think they can have both a wilderness and a broad highway are mistaken; the wilderness goes with the canoe, the snowshoe, and the packsack.

In discussing the third phase of this report, the scientific work, it should be said that there are thousands of mysteries connected with our finny creatures. To start with, we need a more thorough study of the sunfishes. We need this because the bluegill, the prince of all the sunfishes, is becoming a "warm-water trout," in effect. Thousands of fishermen have learned to use their trout flies on bluegills, and these anglers will tell you that catching bluegills with such tackle is nearly as much fun as catching trout. Anglers say that bluegills behave similarly to trout on the hook, cause the same swirl in the water, have nearly the same strength and put up a similar battle, and that bluegill fishing is one of the best of all sports.

We do not need studies of the bluegill for the primary purpose of raising and liberating more fish. What we should know is whether the lakes and streams are productive and fertile and whether they can be improved if they are not. It is almost impossible to avoid reference to the club production of fish in Indiana. As you know, the Hoosier clubs raise bluegills, red-eared sunfish, largemouth and smallmouth black bass, crappies, rock bass, and trout, under contract with the State Department. Last year the clubs themselves raised and liberated more than seven million fingerling fish. Six million of the total were bluegills.

When fishermen raise fish, their sentiments change. They become interested in scientific problems. They suddenly assume a new attitude and begin to be concerned about the natural reproduction in our waters. They cease to be violators. Some even become informers, guardians or deputy wardens and become evangelists for conservation and arouse a new public interest. Perhaps this is the most important result of fish production by clubs, but the changed attitude also leads to other beneficial results, such as stream and lake improvement and reforestation.

The artificial propagation of fish has reached astonishing heights, and violations have been reduced to a minimum, which takes care of two of our major problems, but as yet, in most states, little is being done to stimulate natural propagation or to improve conditions for aquatic life. We need more research on these problems and we cannot afford to give our attention wholly to trout or to any other single class of fishes. If we would find out more about our lakes it may be that we shall have to raise our creel limits on some species, such as bluegills and red-ears, and even urge that people do more fishing for the sake of the sport. This is a somewhat radical idea, perhaps, but an idea nevertheless that is suggested for whatever it is worth. Some of our lakes actually may be overstocked, and there may be a problem of either taking out more fish or improving the fertility of the lake.

Very little is known concerning the fate of hatchery-reared fish after they are planted. Many questions remain unanswered. For example, what are all the sunfish of various sorts that do not seem to fit any particular classification, and does the bluegill with a triangle-shaped ear differ from the ordinary bluegill? Billions of wall-eyed pike have been planted. Where are they? How many nests of bluegills should maintain the bluegill stock in a 100-acre lake? What may be expected from the thousands of new artificial lakes that have been formed?

The same situation of lack of knowledge applies to bass and catfish. You may be surprised that anyone would mention catfish to an angler, but it should be remembered that two species of catfish in the Mississippi system will grow from 50 to 100 pounds or more in weight. Angling for these big fish is developing into quite a popular sport. In several sections of the Middle West the cat-

fishes already rank with the other game fishes. They will always remain food fishes, of course, and will be commercial fishes, but they will be sought also with heavy sporting tackle, possibly with salt-water tackle. The commercial fishermen have not questioned the future of the catfish, but have the lumberman's attitude. Their purpose is to take and sell but, now that the anglers are becoming interested, the conservation sentiment will increase. The sportsmen are going to take means to insure the availability of more 100-pounders. The time may come when angling for big catfish will be just as popular a sport as angling for salmon in Canadian coastal streams, or the trolling for sailfish.

It should be emphatically stated that the problems with regard to warm-water fishes are not localized; they cover a vast territory, much larger than the restricted sections where the chief interest is in trout or salmon. Bluegills (also locally called panners or bream) are an important fish to millions of fishermen from one end of the country to the other. The catfishes, bass, and other species of warm-water fishes have even a wider range of interest than the bluegill. This Society should give more attention to those species that serve anglers of the vast areas that never knew and never can know the charr or the rainbow trout. Let there be no misunderstanding—increased attention should be given to warm-water species without subtracting to the slightest extent from the consideration afforded cold-water fish.

In summary, here are the recommendations: First, that we study the natural baits, with a view to recommending that commercial bait dealers raise them in ponds; second, that we interest the sportsman in the Great Lakes fisheries; third, that we give more attention to limnology and to the warm-water species without detracting from the studies of cold-water fishes.

# REPORTS OF STANDING COMMITTEES

## REPORT OF THE COMMITTEE ON FOREIGN RELATIONS

Charles E. Jackson

The Committee on Foreign Relations submits herewith a resume of the status of international fisheries which involve the United States and neighboring countries. In addition to those mentioned herein, there are several fisheries matters approaching the initial stage which have not developed sufficiently at the present time to justify a report.

### International Control of Great Lakes Fisheries

At a conference held in Detroit, Michigan, February 25 and 26, 1938, under the auspices of the Council of State Governments to consider the problems of fishery conservation of the Great Lakes, which was attended by representatives of the states bordering the Great Lakes, the State Department, Bureau of Fisheries, and Province of Ontario, a resolution was adopted unanimously requesting the State Department to discuss with the appropriate Canadian authorities the advisability of a treaty to establish an International Board of Inquiry whose function it would be to recommend measures for the conservation of the Great Lakes fisheries. The conference recommended the conclusion of such a treaty.

At a second conference held by the Council of State Governments in Chicago on December 5, 1938, the previous action was reaffirmed and following discussions with the representative of the Province of Ontario further conversations were held between the State Department and the Department of External Affairs of the Dominion of Canada.

In January, 1939, the Canadian authorities offered a counter proposal that a

Board of Inquiry of four members, two to be appointed by each of the governments concerned, be established by a formal exchange of notes rather than by a treaty and it was understood that such a plan will be followed.

Tentative selection of personnel and preliminary planning of the activities of this Board of Inquiry are now proceeding and it is believed that final action on the appointment of the Board will be taken within a few weeks.

It is anticipated that such a Board of Inquiry will hold a series of public hearings in the Great Lakes region assembling in compact form all available information regarding the status of the fisheries, the methods of administration, the need for coordinative control, public sentiment for the various methods of control, and the possible character of an international treaty to provide such unified control.

## Japanese Fishery Activities in Alaska

Japanese floating plants began exploitation of the king or spider crabs in Bristol Bay in 1930, when the cannery *Taihoku Maru* (7,834 tons), with a trawler and several power launches, was operated in the district and was said to have packed over 20,000 cases of crab meat. Since that time from one to four floating plants, together with their auxiliary vessels, have been engaged each year.

Although operations have been directed chiefly to crab fishing and canning, one vessel has been used for the manufacture of meal and oil from bottom fish taken by trawling. In 1936 a floating salmon cannery that had been licensed to operate off the Siberian coast entered the Bristol Bay district for a time, since fishing in its normal place of operation was delayed by ice conditions.

In 1936, also, an extensive study of the routes of migration and availability of salmon in Bering Sea waters was begun under the auspices of the Japanese Government. This expansion of Japanese activities with respect to the salmon fishery alarmed Bristol Bay packers, and strong protests were made against the threatened encroachment on the Alaska salmon fisheries.

Diplomatic negotiations between the countries involved finally resulted in assurances by the Japanese Government in the spring of 1938 that it would suspend its official survey of salmon resources in the waters of Bristol Bay and that it would continue to suspend the issuance of licenses for vessels to fish for salmon in these waters. In so far as known, there has been faithful adherence to this policy.

Only one Japanese crab cannery, the *Toten Maru* (2,951 tons), was operated in Bristol Bay waters in 1938. It was accompanied by three 50-foot trawlers and ten launches about 30 feet long, and it left the district before the salmon runs began. This vessel also returned to Bristol Bay in the spring of 1939 to engage exclusively in crab fishing. Official reports indicate that its operations there were discontinued before the first of June.

The entire problem of protecting and conserving the Alaska fisheries is receiving constant and practical attention by various branches of the Government.

The Japanese training ship *Hakuyo Maru* (1,327 tons), of the Tokyo Fisheries Institute, plans to visit certain Pacific ports of the United States this summer, including a call at St. Paul Island on July 12 and 13 for the purpose of giving its students an opportunity to acquaint themselves with conditions in regard to the breeding of fur seals and the facilities provided for their protection while breeding. The Japanese Government is one of the signatory powers in the North Pacific Sealing Convention for the protection of fur seals and sea otters of the North Pacific and has an interest in the sealing operations carried on by the United States at the Pribilof Islands, receiving 15 per cent of the annual take of fur-seal skins there. The United States, in turn, receives 10 per cent of the take of skins from the fur-seal herd that has its breeding grounds on islands under Japanese jurisdiction. The other signatories to the North Pacific Sealing Convention are Canada and the Union of Soviet Socialist Republics.

The cruises of the *Hakuyo Maru* are concerned not only with fur seals, but give the students opportunity to learn deep-sea fishing. The vessel has a comprehensive library and oceanographic equipment for scientific study of marine life in all its branches, and there is a small outfit for experimental canning of salmon and crabs. The *Hakuyo Maru* has made cruises in the Bering Sea during several previous seasons.

### International Fisheries Commission

The International Fisheries Commission, created by convention between the United States and Canada, continues to show outstanding progress in the rehabilitation of the North Pacific halibut fishery. Its success demonstrates what can be accomplished by the rational control of a badly depleted fishery and proves the feasibility of international control of international fisheries.

It will be recalled that the halibut fishery had a history of decline prior to its regulation by the Commission. The Commission's investigations have shown a decline in abundance of 87 per cent from 1907 to 1930 on the longer-fished southern grounds off the coasts of British Columbia and southeastern Alaska and a decline of 75 per cent from 1915 to 1930 on the western banks off the coast of central and western Alaska. Total annual landings decreased after 1915 in spite of a continual increase in the amount of fishing. The decline in abundance was accompanied by a great reduction of the spawning stock on the western grounds and by the virtual elimination of spawners on the southern grounds. A partial cessation of fishing due to economic conditions in 1931 interrupted the decline. Control of the intensity of fishing in subsequent years by the Commission has resulted in a remarkable improvement in the condition of the halibut stock.

Regulation of the fishery is based upon a wide range of biological, statistical and oceanographic investigations and is guided by current biological and statistical observations of the changes in the condition of the stocks of halibut that occurred as a result of regulation. Noteworthy are the definition of the different stocks of adult fish by means of marking experiments and racial studies; the determination of spawning banks that contribute to the different stocks by an investigation of the ocean currents and of the drift of the pelagic eggs and larvae; the annual evaluation of the production of eggs and larvae by means of net hauls at sea during the spawning season; a continuous sampling of the commercial catches to determine the size- and age-composition of the different stocks and the changes therein; and the collection and analysis of the records of individual fishing operations whereby the changes in the relative abundance of the fish on the banks are ascertained.

The abundance of fish is now 77 per cent higher on the western grounds and 100 per cent greater on the southern grounds than in 1930, the last year of unrestricted fishing. The number of mature fish on the badly depleted southern grounds and the production of eggs and larvae have increased steadily during the last few years, assuring a greater stock of fish for the future. Due to the improved condition of the stocks the fishermen are now obtaining annually the same amount of fish as in 1930 with the expenditure of only one-half to two-thirds as much effort. On the southern grounds they are actually obtaining several million more pounds of halibut annually in a short fishing season than would now have been possible during a long fishing season if fishing had continued unrestricted. Thus both the stocks of fish and the fishermen have benefited by the efforts of the Commission.

### International Pacific Salmon (Sockeye) Fisheries Commission

#### THE FRASER RIVER SALMON CONVENTION

The Sockeye Salmon Fisheries Convention was signed in 1930, but ratifications were not exchanged until July 28, 1937, after the agreement of certain understandings. The Convention applies to the territorial waters and high seas to the westward of Canada and the United States between 48° and 49° North

Latitude, the Straits of Juan de Fuca, the major part of the Straits of Georgia, and the Fraser River. The treatment of national sovereignty by this Convention is interesting. Regulations enacted by the International Pacific Salmon Fisheries Commission which was created by the treaty, will be enforced within the territories of each nation solely by the government of that nation. On the high seas an offender may be seized by either nation but can be prosecuted only by his own. Removal of obstructions to migration may be *recommended* to the two governments, but action must be agreed upon in each case before any expense will be borne equally by the two. Land needed by the Commission may not be acquired by it, but each High Contracting Party shall "acquire and place at the disposition of the Commission any land within its territory required" for its purposes.

The Convention was ratified subject to certain conditions or understandings. The first guards the right of the respective governments to authorize types of gear independently of the Commission. The second delays application of regulations for eight years. The third provides for an advisory committee from the salmon seine, gill and troll fishermen and the sportsmen.

The Commission at first consisted of A. L. Hager, Wm. A. Found and Tom Reid for Canada, and of Edward W. Allen, Charles E. Jackson and B. M. Brennan for the United States. In February, 1939, Wm. A. Found resigned and was replaced by A. J. Whitmore. The powers of the Commission, as detailed by the treaty, include regulation, study of the natural history, the conduct of fish-cultural operations, the care of the spawning grounds, and the recommending of the removal of obstructions to migration.

The Commission met in 1937, organized, and elected Mr. Hager, Chairman, and Mr. Brennan, Secretary. The Commission established headquarters at New Westminster, B. C., and chose Dr. W. F. Thompson as Director of Investigations. An Advisory Committee was chosen and a first meeting was held with it in Vancouver.

The scientific program was well under way at the end of the 1938 season. A survey of the river and its runs of salmon saw the completion of the first year of a cycle of four. The collection and analysis of the great mass of existing material regarding the past runs of sockeye salmon in the Fraser River was in good part completed. Over 5,000 sockeye were tagged, with over 50 per cent returns. Large numbers of the tagged fish were from the spawning grounds, which was not true in previous salmon tagging experiments. The time and place of occurrence in the commercial catch of the races belonging to the various spawning grounds, their passage up the river and the time, manner and locality of their spawning were studied by means of the recovery data.

An interesting method, new so far as salmon are concerned, was developed for the enumeration of the numbers escaping the commercial catch. The escapement that can be determined by direct observation and enumeration is far from accurate and the regulating officials have long known that numbers of fish going to a great many lakes and deeper streams escape observation. Because it is impractical to place weirs in many places in the tributaries, a method using samples of marked fish was tried experimentally, particularly at Cultus Lake, and was very successful. It is hoped to try the method on a larger scale this year. It is possible that by the use of the tagging method a passably accurate determination of the year by year escapement to each spawning ground may be obtained.

Several major problems have been encountered by the Commission. One of the most important of these is the identification of fish native to streams other than the Fraser River. Another is the foundation of an adequate system of collecting the statistics and other information needed for regulation. A third is that of the large lakes and streams tributary to the Fraser which are at present not frequented by sockeye salmon. An extensive study of obstructions will be required. Programs designed to afford information concerning these problems are well under way this year.

The collection of needed facts in a careful and thorough manner, a procedure now recognized everywhere as necessary to any adequate regulation, has been begun. The first year's program, exploratory and preliminary, was not as complete as that of the second year will be, but it forms a worthy beginning on the eight years, or two life cycles of investigation contemplated when the treaty was ratified.

### North American Council on Fishery Investigations

The North American Council on Fishery Investigations was organized in 1921 because of international concern over the threatened depletion of several important species that support the rich fishing grounds from the Grand Banks of Newfoundland to Cape Cod. The annual meetings of the Council serve to pool information gathered by scientists of the member nations as a basis for preventing further depletion and restoring valuable fish populations to safe levels of abundance. Each of the nations belonging to the Council carries on its own program of scientific studies, financed by governmental appropriations. The Council functions as an international advisory body that makes recommendations for maintaining the fisheries at productive levels. For example, a recent recommendation of the Council, based on studies of the Bureau of Fisheries, resulted in a voluntary agreement by operators of United States otter trawlers to adopt gear with a larger mesh size to permit the escape of undersized haddock.

The present members of the Council are Canada, Newfoundland, France, and the United States.

The twenty-fifth meeting of the Council was held at Boston, Massachusetts, October 4 to 7, 1938. At the same time the commercial fishery industries were holding their fishery exposition and convention in Boston. The Council invited the members of the Fishery Advisory Committee of the Department of Commerce and other leaders of the industry to attend a general session on October 5, at which time a general discussion of fishery problems in the North Atlantic areas was held and the program of fishery investigations by Newfoundland, Canada, and the United States was presented.

Nearly a score of fishery investigators in the various services were present who participated in sectional committee meetings dealing with ground-fish investigations, shore fish studies, hydrographic research, and fishery statistics giving the official members of the Council a summary review of progress made during the year in these fields and permitting them to modify their official programs accordingly.

The meetings of the Council are particularly useful in affording an opportunity for the investigators of the several fishery departments to meet for a discussion of their technical problems and to exchange experiences and opinions regarding methods, objectives, and results.

---

## REPORT OF THE COMMITTEE ON COMMON AND SCIENTIFIC NAMES OF NORTH AMERICAN FISHES

Walter H. Chute

The Committee on Common and Scientific Names of North American Fishes originally was appointed in 1933 as a result of a resolution proposed and adopted at the 1932 meeting of the Society. The Committee was formed "to prepare and submit for publication a list of standard common names of fishes corresponding to the accepted scientific names." Pressure of other duties and absence on field trips prevented this committee from functioning up to the last meeting of the Society in 1938, except to agree on several points of general policy, as reported by the former chairman at the 1935 meeting. At the Ashe-

ville meeting last year this committee was reorganized, and at the present time the membership is as follows: William J. K. Harkness, Samuel F. Hildebrand, Carl L. Hubbs, A. H. Leim, George S. Myers, Leonard P. Schultz and Walter H. Chute, Chairman.

A sincere effort was made by the nominating committee to appoint representatives from each geographical district. It has been pointed out, however, that the Pacific Coast has only one representative now actually engaged in fisheries work there and that the Gulf States lack representation. It may be well, in view of the duplication in common names between these areas and other parts of North America, to increase the membership of the committee to allow for such representation.

Early during 1939 the chairman prepared three preliminary lists of names of familiar fishes, one for the Atlantic Coast, one for the Pacific Coast, and a third for fresh-water fishes. These preliminary lists contained a total of 439 names of fishes. Copies were sent to each member of the committee with requests for corrections, omissions and additions. In the first two lists returned seventy additional fishes were named. All of the members of the committee have not returned their lists, but if the same rate of increase persists the Committee will have well over 600 names to consider and fully 30 per cent of these are controversial. As this work must all be done by correspondence, and all of the members of this committee are very busy men, it will of necessity be some time before an acceptable list can be prepared.

The chairman of this committee does not anticipate difficulty in securing the proper scientific names for the fishes selected for the final list. This committee is fortunate in numbering in its membership some of the foremost taxonomists of the day and the chairman is certain that any list of names agreed upon by these gentlemen will be acceptable to the Society at large. Unfortunately the selection of standard common names for these fishes is an entirely different matter. There is no governing body to issue rules or methods of procedure in such matters; many of the names in present use were applied without apparent reason and in utter disregard of the physical characteristics of the fishes or their relationship to similar species in other localities.

It is not the desire of the chairman of this committee to engage the Society in a debate on such a controversial subject. It would be very helpful to this committee, however, if the desires of the membership of the Society were expressed on such questions as, "Shall the standardized lists of names of fishes contain any duplicates, even though the fishes bearing the same names are located in widely separated areas?" and "Shall names be retained which, though widely used, were originally applied in error as to the family affiliations of the fish?"

The chairman would like nothing better than to be able to submit a preliminary list at this meeting but for the reasons outlined above this has been impractical. However, a start has been made and it is sincerely hoped that at the next meeting at least a partial list can be prepared that will be acceptable to a majority of the members of the Society.

## REPORT OF THE PUBLICATIONS COMMITTEE

JOHN VAN OOSTEN

It has not been customary for the Chairman of the Publications Committee to submit a report to the Society. However, I believe that the time has come to speak rather pointedly concerning some of the problems that have confronted us in editing the Transactions. I wish it to be understood clearly, however, that the comments and criticisms in this report are not directed to fish-culturists, administrators, or others who have had no experience in writing scientific papers. These remarks are directed largely to the older, experienced

authors—people who should be able to write a good scientific paper. Many fish-culturists, for example, have not had sufficient training to enable them to write a good scientific paper, and the members of the Publications Committee have been and will continue to be willing to do anything in their power to improve papers submitted by such fish-culturists. The same consideration will be shown the younger scientists who are presenting papers for the first time.

For the last three years a determined effort has been made to improve the standards of our Transactions. Acting on the realization that a good volume must originate in well written manuscripts, I prepared an outline of instructions to authors that not only set forth definite and specific directions as to the mechanical arrangement of manuscripts and as to the general style to be followed, but also called attention to the more common faults that were to be avoided. These instructions, which have been distributed to prospective authors and have been printed three times in the Transactions, were not drawn up arbitrarily but were condensed from the regulations contained in the best style manuals (Government Printing Office Style Manual; University of Chicago Style Manual). It should be explained also that certain of the regulations that may appear unnecessary to the authors are nevertheless essential parts of a procedure that ensures the proper handling of materials in the printing establishment.

The early results of this campaign to better the quality of the Transactions were disappointing but not altogether surprising. However, an improvement in the manuscripts was justly expected from year to year. Consequently, when it became obvious that the manuscripts submitted in 1938 were scarcely, if at all, better prepared than those of three years earlier, the patience of the Committee was sorely tried.

The attitude of the committee toward the unnecessary work that has been occasioned by the carelessness of authors in the preparation of manuscripts is summed up well by the following quotation from a letter written to me by a committee member, who had just completed the editing of a particularly difficult paper:

> ". . . the preparation appears to have been made with total disregard, not only of the Society's regulations in particular, but also of all generally accepted standards of good taste and sound procedure in writing scientific papers. As a typical illustration, there were one error and two rule violations in connection with the footnote on the title page. Enclosed you will find two typewritten pages on which other infractions of rules, errors or violations of sound procedure are listed.
>
> "For fear my following remarks may be misunderstood, I wish to state most emphatically that I am in complete sympathy with the move toward the improvement of the publication standards for the Transactions. Furthermore, I am willing to devote such time as may be necessary for a careful editing of papers—provided the authors themselves exhibit a similar interest in the quality of their productions. Nevertheless, I feel that there is a limit beyond which the work of the editorial committee should not extend.
>
> "As specific examples—I do not believe that a committee member should have to get out a pencil and ruler and block off the column headings of tables, as I had to do in this paper. Neither should he have to check horizontal alignment, which in one table was so bad that printing errors very probably might have resulted. Nor should he have to check the terminology in the body of tables to insure that there is consistency between different portions of the same table. Furthermore, committee members should not be called upon to write titles and prepare title pages for figures, or to excise tables from the manuscript and paste them on new pages. I could continue this series of citations, but those given serve adequately as illustrations. Such 'kindergarten' details should certainly be handled by any author. To load them on the shoulders of the editorial committee is not

only unjust, but is certain to reduce the efficiency of the committee's work.

"For two years now the editorial committee has practiced patience in excess, although the goal in mind has probably justified the great forbearance. I believe, however, that the time has now come for authors to write their own papers. I suggest that in the future those authors who care so little for the quality of their publications that they decline to prepare them properly or even to do a reasonably good job of reading copy should simply be requested to print their materials in other publications with lower editorial standards."

The continuation of our present method of editing the Transactions is unthinkable. It is entirely too much to expect committee members to continue to devote their time and energy to the revision of papers that were prepared, as the committee member so pointedly stated, with total disregard for instructions and for good usage. As proof that I do not exaggerate the difficulties that the Committee faces, let me cite the following statistics concerning papers presented at our 1938 meeting: Thirty-six papers were received for publication; two were rejected and thirty-four were published. These thirty-four manuscripts comprised 308 printed pages. Nineteen papers, or 61 per cent of the 308 printed pages, were returned to the authors for correction or revision. Seven papers, or 28 per cent of the printed pages, were returned twice. Considerable portions of twenty-five manuscripts, or 74 per cent of the total published, had to be rewritten by committee members.

The careless preparation of manuscripts not only has placed undue burdens on the Publications Committee, but it has also brought about an unreasonable delay in the publication of the Transactions. There is no question but that easily avoidable defects in the manuscripts submitted last year have delayed the appearance of the volume by fully four months. Had we rejected all papers that could not be edited within a reasonable space of time, the Transactions of the 1938 meeting would have been little more than half the present size, but they would have appeared last winter. The immediate rejection of poorly written papers would also have spared the committee members the great amount of labor involved in handling a considerable mass of correspondence.

Most authors are probably wholly unaware of the amount of time required for the careful editing of a single paper. The duty of the committee does not consist of a perfunctory leafing through the manuscripts. The total number of detailed examinations to which each paper is subjected, either as manuscript or as proof, is at least nine. If the papers have to be returned to the author for revision, this total number is increased.

I wish to emphasize that the insistence of the Publications Committee on the submission of well prepared manuscripts is not mere fussiness. We have been working toward a very definite objective, namely, that the Transactions shall contain only papers which are logically arranged and written in good, clear English, and which contain only valid conclusions, based on sufficient and adequately presented data. I do not believe that the Publications Committee has been unduly meticulous or overexacting in its treatment of manuscripts submitted to it. In fact, with a single exception, all authors have stated that our work has improved their papers, and have expressed appreciation of our editorial efforts. We, in turn, have appreciated their commendation. In the future, however, the Committee, I am sure, will prefer cooperation to approval.

Circumstances appear to dictate a change of policy in the operations of the Publications Committee. As chairman, I therefore recommend that, beginning in 1939, that is, with the Transactions of this meeting, the work at the rewrite desk be ended. Manuscripts that are poorly written or arranged illogically, and manuscripts that contain persistent violations of the instructions to authors, should be returned immediately for revision. If satisfactory changes are not made, the papers should not be accepted for publication. I do not suggest that the Committee be unreasonable and stop short at the sight of a split

infinitive or a mixed metaphor. On the other hand, I do believe that the Committee should refuse to continue its career of "ghost writing."

I wish to call attention to another problem—one that concerns the Society as a whole—namely, the increasing size of the Transactions. Unquestionably, we have reached the point where it is financially impossible to publish every paper that is submitted. This problem can be solved without detracting from the value of the Transactions by the imposition of further limitations on the number of papers to be accepted from any one member and by the publication of certain papers in the form of abstracts.

At present we limit our members to two papers in each volume of the Transactions. I believe that in the future we should set the limit at one paper except in those situations when the President may request certain authorities to prepare articles on specially assigned topics, or when relatively few papers are submitted for publication. Members should be permitted to continue to present two papers at our meetings if they wish to do so, but publication of the complete text should be limited to a single paper. Only an abstract of the second should be included in the Transactions.

Further retrenchments can be accomplished if the Publications Committee will discriminate between papers of purely transitory interest and those of permanent value to persons engaged in fisheries investigation and management. Articles that contain permanent contributions should be printed in their entirety, but the publication of many progress reports and outlines of local programs may well be limited to abstracts.

It falls entirely within the constitutional powers of the Publications Committee to impose these limitations that were suggested as a means to halt the constant increase in the size of the Transactions. However, the enforcement of the limitations would constitute such a radical departure from earlier procedure that I believe that the Committee should first seek the approval of the Society as a whole. I hope that the Society will recognize the necessity for restrictions on the quantity of material to be included in the Transactions and will enact a resolution supporting the Publications Committee in its efforts to keep costs of publication within the means of the organization.

Finally, I feel that I should mention that our Transactions have, on occasion, been made to appear in a bad light by reason of the prior appearance of certain papers in other publications. I suggest, therefore, that in the future, papers be accepted for publication only with the understanding that they are not to be submitted for publication elsewhere until the printed volume of the Transactions has first appeared, and with the further understanding that any subsequent publications of the same material shall be clearly designated as reprints from the Transactions. Neither should the Publications Committee accept materials that are to appear in other publications in only slightly modified form. If we do not receive cooperation in this matter each volume of the Transactions should be copyrighted. As an alternative, the facilities of the Transactions should be denied to offending authors.

---

THE PRESIDENT: The applause indicates acceptance by the membership of this frank and constructive criticism. Are there any suggestions from the floor?

MR. GORDON: I have no suggestions to offer, except to say that, having certain responsibility in the matter of expenditures, it occurs to me that perhaps the Chairman of the Committee is unduly apprehensive about the size of the volume. The size of the volume could not ordinarily go much beyond the volume of last year, of which I have only the final page proofs, without wrecking the finances of the Society.

One thing we have to keep in mind is that in the last couple of years we have

been running on a two-day basis, with possibly evening sessions, whereas in former years it was not unusual to have a three-day session. Because of the special conferences on Wednesday, with the Bureau of Fisheries in the forenoon and the Biological Survey in the afternoon, it was necessary to confine our program to two days. Any program that can be handled within two days, provided we do not read too many papers by title only, should be within the financial scope of the Society's means. I should not be so much concerned about reducing the size of the volume as with securing the right quality of material and keeping the interests of the practical or management workers—let us say, the fish-culturists and the administrators—as well as the interest of scientific workers, so that we shall have one composite body of the entire membership instead of finally splitting ourselves up into two or three different factions.

In his prefatory remarks Dr. Van Oosten very carefully stated that the criticisms were not directed to the fish-culturists, not to the administrators so much as to those who are looked upon as scientific workers and who are careless in the preparation of their manuscripts. I have observed that as a rule fish-culturists can tell their story in language which the average man can understand fairly well. He may not always use 100 per cent perfect English, but he gets his message across in a clearer way to the average person than does the average scientific worker who is preparing a paper. Therefore you cannot be too hard-boiled, as Dr. Van Oosten indicated, in editing certain types of papers; and the committee has carefully avoided tearing to pieces certain types of manuscripts. But I do know that the Publications Committee has had a tremendous task to perform; I have handled these manuscripts myself a few times and I know something about it. They have done an exceptionally good job in placing the Transactions on a higher plane, so that the annual volume will be recognized as a scientific publication as well as a practical handbook.

# REPORTS OF SPECIAL COMMITTEES

## REPORT OF THE POLLUTION STUDY COMMITTEE

TALBOTT DENMEAD, *Secretary*

One of the assignments given to the Pollution Study Committee last year at the convention in Asheville was to follow up the question of federal control of pollution. I am wondering if the members of the American Fisheries Society really have considered seriously what pollution means to them. I wonder if they have ever contemplated the fact that if there were no pure waters they would have no jobs. There would be no use for the Bureau of Fisheries, and it would be futile for the state fish-culturists to raise fish if there were no clean waters in which to put them. There would be no use in studying the diseases of fish if the fish are to be put into waters that are poisoned. In other words, to a great extent the jobs of a great many of you present here today and of members of our association generally actually depend upon pure waters.

Perhaps you consider that the question of pollution is not a serious one in your state or in your section, and perhaps you do not know of polluted conditions that exist. The pollution situation today in the United States is not much better, if any better, than it was when we met a year ago.

The Society endorsed the Lonergan bill, Senate No. 13, and several years ago your committee was instructed to follow that up. I have examined our present program very carefully and I find only one paper on the question of pollution, nor do I see any papers on pollution on the program of the convention which follows ours, that of the International Association of Game, Fish and Conservation Commissioners. It seems to me that pollution is a subject in which we should all be vitally interested.

There are at the present time six or seven bills on the question of pollution pending in Congress. The Barkley bill provides practically nothing but appropriations for the next ten years to investigate pollution; it does not do a single, solitary thing to clean up, as I told you last year, even a bucket of pollution. The Mundt bill, filed by Congressman Mundt of South Dakota, of which I have a copy here, is practically the old Senate No. 13 filed by Senator Lonergan. It is the bill which this Society has endorsed on several occasions and which your committee has approved. I think the majority of the committee members is in favor of the Mundt bill. However, I am expressing here my own opinion and not the opinion of the committee or that of the Bureau of Fisheries.

The principal parts of the Mundt bill are as follows: Administration of the provisions of the bill is placed under the Chief of Engineers of the United States Army instead of the Public Health Service. It provides that the Chief of the Bureau of Biological Survey, the Commissioner of Fisheries and the U. S. Public Health Service heads shall advise the engineer. It provides for complete cooperation with state agencies. It provides for interstate compacts, which have been used to a great extent for some time with fair success. It provides for studies and surveys, and for loans and grants. All the bills so far have provided for state and political subdivisions. Individuals may obtain loans for sewage treatment plants. The Mundt bill provides that when a duly constituted authority to enforce the provisions of the act is in existence, action by the federal authority will be taken only after such existing authorities have been given an opportunity to act. That is the difference between this bill and the others. It gives the federal government some police powers. It takes effect, if passed, two years from its passage, which provides an opportunity to clean up pollution.

I have been told by those who are behind this measure that it is not the in-

tention immediately to "put the screws" on any polluter, but the idea is to use the legislation as an effective means of getting the polluters to control their pollution.

I have a letter here from Congressman Mundt, dated June 15, from which I will read three paragraphs:

"It is beginning to look as though we are going to have a good fighting chance to have this bill, H. R. 6723, substituted for the Barkley bill when the matter comes before the House for consideration.

"It is impossible to say just when this bill will reach us for debate on the floor, but I am inclined to think that it is likely to come before us some time in the neighborhood of about ten days.

"I trust that you will be able to get a resolution from the American Fisheries Society at its annual convention, and if you will send me such a resolution I shall be glad to put it in the Congressional Record and make what use of it I can to help the good cause along. We are going to need every bit of support we can get if we are to be successful in winning this fight."

I understand that it is the will of the committee that some resolution shall be framed, and it is my intention to take up the matter with the Resolutions Committee. When the resolution comes before the meeting you will then have a chance to discuss it if you wish to do so.

I do want to impress upon you, though, the importance of pollution. There is an old saying that "he is also idle who could be better employed." I am afraid some of us fish-culturists and others interested in fish will not be employed at all if we do not clean up our waters.

---

THE PRESIDENT: The Committee on American Fish Policy, by general agreement, has not prepared a report for this meeting. The Policy has been mimeographed, as you know, and distribution made to the membership; it will also appear in Volume 68 of the Transactions. Some suggestions have been received by the Committee, but it was deemed advisable to let the whole matter mature for one additional year before the Committee attempted to recommend any changes in the Policy.

The Pollution Committee and the American Fish Policy Committee are special committees which must be continued from year to year. I will entertain a motion for the continuance of these two committees.

MR. I. T. QUINN: The thought occurs to me that since we do not know just how soon the Mundt bill or the Barkley bill will come up for passage in the House, at which time Congressman Mundt expects to offer an amendment to substitute his bill for the Barkley bill, it would be apropos if a resolution could be prepared immediately and forwarded to Congressman Mundt in Washington, because twenty-four hours' delay might prove fatal. I think it would be advantageous to Congressman Mundt if he had a good resolution from this Society, and if we delay another day the resolution might reach him too late for his use. I was just wondering, therefore, if it would not be well for the Resolutions Committee to prepare a resolution at once so that it could be forwarded by air mail to Congressman Mundt during the day.

THE PRESIDENT: If Mr. Quinn can prevail upon the Chairman of the Resolutions Committee to submit such a resolution this afternoon, it will be acted upon immediately and, if necessary, wired to Washington.

Do I hear a motion to continue the two committees?

MR. F. A. WESTERMAN: I shall be glad to move that the two special committees be continued for at least another year.

(The motion was seconded by Dr. Scott and carried unanimously.)

---

## APPOINTMENT OF COMMITTEES

*Auditing Committee*

P. J. Hoffmaster, *Chairman*, Michigan.
T. H. Langlois, Ohio.
Joe R. Hogan, Arkansas.

*Resolutions Committee*

J. D. Chalk, *Chairman*, North Carolina.
Alan C. Taft, California.
L. R. Donaldson, Washington.
H. H. MacKay, Ontario.
W. H. Chute, Illinois.

*Nominations Committee*

Fred A. Westerman, *Chairman*, Michigan.
I. T. Quinn, District of Columbia.
G. C. Leach, District of Columbia.
H. S. Davis, District of Columbia.
Señor Juan Zinser, Republic of Mexico.

*Committee on Time and Place*

P. R. Needham, *Chairman*, California.
Russell Hunter, Connecticut.
B. O. Webster, Wisconsin.
R. G. Parvin, Colorado.
A. L. Pritchard, British Columbia.

*Committee on Publications*

Following the 69th Annual Meeting, President-Elect Langlois appointed Dr. H. J. Deason, Ann Arbor, Mich., to the Committee on Publications for a term of five years, to succeed Prof. W. J. K. Harkness, Toronto, Canada, whose term had expired. Doctor Van Oosten was persuaded to accept the chairmanship of the Committee for another year, which now consists of the following:

| | *Term expires*[1] |
|---|---|
| Dr. H. J. Deason, Ann Arbor, Mich. | 1944 |
| Dr. Ralph Hile, Ann Arbor, Mich. | 1943 |
| Dr. Lauren R. Donaldson, Seattle, Wash. | 1942 |
| Dr. Paul R. Needham, Palo Alto, Calif. | 1941 |
| Dr. John Van Oosten, *Chairman*, Ann Arbor, Mich. | 1940 |

# REPORTS OF COMMITTEES

## AUDITING COMMITTEE

Mr. P. J. Hoffmaster: Your Auditing Committee has checked the books of the Society, also the supporting vouchers, for the period July 1, 1938, to June 15, 1939, and finds the report as submitted to be correct. This Committee recommends that the appropriation for clerical and stenographic services for the fiscal year 1939-40, exclusive of expenses incident to the preparation, proof reading and indexing of the Transactions of this meeting, be the same as heretofore, namely $350.00.

I move that the report of the Committee be approved.

(The motion was seconded and carried unanimously.)

[1]Indicates the annual meeting at which the term of each member of the Committee will expire.

## COMMITTEE ON RESOLUTIONS

MR. J. D. CHALK: Your Committee recommends the following resolutions for adoption by the Society:

### *1. Endorsement of Mundt Pollution Bill*

(Adopted previous day and submitted as part of report)

WHEREAS, The problem of preventing the pollution of the waters of the United States is a serious one; and

WHEREAS, It is believed, after careful consideration of the bills now pending in Congress regulating pollution in navigable waters, that the only one that will be effective in the reclamation of our polluted waters and the cessation of further pollution is H. R. 6723:

The American Fisheries Society, therefore, at this sixty-ninth annual convention, held in San Francisco, California, this 26th day of June, 1939, hereby commends H. R. 6723, and respectfully urges its immediate passage.

The Secretary is instructed to wire the substance of this resolution to Hon. Karl Mundt who introduced the measure at Washington, D. C., and to send copies to other interested organizations and individuals.

(Upon motion, duly seconded, the resolution was voted upon and unanimously adopted.)

### *2. North Pacific Fishery*

WHEREAS, Canada and the United States have set a splendid example of cooperation for the preservation of fisheries in which the nationals of both countries participate by the creation of the International Fisheries Commission and the International Pacific Salmon Fisheries Commission; and

WHEREAS, The accomplishments of these Commissions as well as the preservation of the fishery resources of the Pacific coast of Canada and the United States generally may be seriously imperiled by the invasion of these fisheries by vessels and citizens of other nations which have never until recently participated in these fisheries, and which have in no way contributed to their conservation or development:

BE IT RESOLVED, That Canada and the United States be urged to survey the entire north Pacific fishery situation of America and to formulate a plan of procedure which, without prejudicing the present privileges of the fishermen of either nation, will effectuate a sound conservation policy for all of these fisheries.

BE IT FURTHER RESOLVED, That copies of this resolution be forwarded to the appropriate departments of both nations.

(Upon motion, duly seconded, the resolution was voted upon and unanimously adopted.)

### *3. Tribute to Deceased Members*

WHEREAS, The American Fisheries Society has experienced the loss of four valued workers in the passing of Dr. George C. Embody, Dr. William C. Kendall, W. M. Keil and Earl E. Hoover; and

WHEREAS, Three of these members have been actively associated with the work of this Society for many years and the fourth showed great promise of equal devotion and accomplishments in the cause of conservation:

BE IT RESOLVED, That the American Fisheries Society in Sixty-ninth Annual Conference held at San Francisco, California, this 27th day of June, 1939, deeply feels their loss and hereby expresses its sincere sympathy to their bereaved families; and

BE IT FURTHER RESOLVED, That a copy of this resolution be forwarded by the Secretary to the respective families of our deceased friends and co-workers.

(Upon motion, duly seconded, the resolution was adopted with a unanimous silent rising vote.)

*4. Appreciation of Courtesies*

Whereas, The Sixty-ninth Annual Meeting of the American Fisheries Society has met in the city of San Francisco, California; and

Whereas, The officials of the State of California and the people of the city of San Francisco have been most kind and cooperative:

Be It Resolved, That we the American Fisheries Society express our appreciation to the Governor of California, to the Division of Fish and Game of California, and to the Honorable Herbert C. Davis, Executive Officer, and to Mr. A. E. Burghduff, of the Division of Fish and Game of California, and to the people of the city of San Francisco, for their courtesies and efficient management in connection with the Convention.

(Upon motion, duly seconded, the resolution was unanimously adopted.)

---

## COMMITTEE ON TIME AND PLACE

Mr. P. J. Hoffmaster: A preliminary meeting was held and consideration was given at some length to the question of rotating the meeting versus a central meeting place; that of changing the date of meetings; and that of combining the meetings of the two organizations with those of other related bodies. We are prepared to report now as to the findings and conclusions of the Committee, but it was felt the matter should be discussed by the membership before the Committee submits a report and recommendation.

The President: I will ask Mr. Gordon to assume the Chair for the purposes of a preliminary discussion on time and place.

Mr. Gordon: I am going to review briefly what took place at a meeting in Detroit on February 15. The executive committees of the two organizations (the International Association and the Society) met to discuss ways and means, time and place, and related matters. I shall sketch very briefly what happened there.

A general discussion ensued concerning the wisdom of consolidating these annual conventions with meetings of other groups interested in conservation and related research, the desirability of holding said conventions during the late summer or the winter months, and the possibility of selecting a convenient central point or points for the meeting place.

In view of the feeling that such a plan would save travel time and expense for all concerned, as well as increase the attendance and effectiveness of our conservation efforts, it was moved, seconded and agreed to that each of the groups below should be invited to designate two (preferably the president and secretary, or their alternates, or in the case of federal bureaus, the head thereof and one other) to meet at some convenient point prior to the June meeting to discuss matters at length in the hope of working out a plan for consideration at the special evening session scheduled at San Francisco: (1) American Fisheries Society; (2) International Association of Game, Fish and Conservation Commissioners; (3) Izaak Walton League of America; (4) American Forestry Association; (5) National Wildlife Federation; (6) American Wildlife Institute (sponsor of North American Wildlife Conference); (7) U. S. Biological Survey; and (8) U. S. Bureau of Fisheries.

I was directed to call that meeting. It was held in Washington, D. C., on June 3.

The American Fisheries Society was represented by Dr. T. H. Langlois, First Vice-President, and William C. Adams, Vice-President of the Division of Protection and Legislation; the International Association of Game, Fish and Conservation Commissioners, by myself; Mr. J. D. Chalk, First Vice-President, failed to arrive because his plane was fogged down. The Izaak Walton League of America was represented by Lewis Radcliffe, one of the national directors; the American Forestry Association by its Executive Secretary; the American

Wildlife Institute by its Acting Secretary; the National Wildlife Federation by Carl Shoemaker, Secretary, and I. T. Quinn, Public Relations Director; the Bureau of Biological Survey by Dr. W. C. Henderson, Associate Chief; the Bureau of Fisheries by Glen C. Leach, representing the Acting Commissioner.

The gist of the discussion was that there are certain organizations which might consolidate their meetings and still retain their individual identity; but when it was all summed up it seemed as though it was almost impossible to get away without at least two big national or international meetings, one in the winter or early spring, and the other in the late summer or early fall. It was decided that the best thing to do was to present all these views to the Time and Place Committee and others present here for their consideration so that the matter might be discussed further.

One of the speakers made a very pertinent statement which I think ought to be mentioned. He pointed out that there is considerable difficulty in separating the International Association and the American Fisheries Society because the two are so closely interrelated. Another speaker pointed out that no joint gathering of a dozen or more groups can be held together successfully for more than three or four days of continuous meetings, and that it would be impossible for all the various groups to crowd their meetings into such a short time. Those of you who are acquainted with the work of the American Association for the Advancement of Science know that it is virtually a twenty-ring circus.

There are members of both organizations who have been deploring the need for so many trips to various parts of the country, so frequently throughout the year. On the other hand there are others who like the idea of travelling about the country to see the conditions in different sections and to give members of the organizations in the regions where the meetings are held an opportunity to attend at least during the years when the meetings are in their own locality, and thus to retain their active interest.

During the last two years our meetings have been held in June. This was done at the suggestion of Dr. Ira N. Gabrielson, in order that he might have a conference with the state game administrators, especially with reference to the waterfowl regulations and the new federal aid program; and also in order that the Bureau of Fisheries might have a conference with fisheries workers.

Dr. Gabrielson says that the waterfowl regulations seem to be going along quite satisfactorily, and that if the administrators are willing to try to work out this matter in some other way, either through regional conferences or perhaps by getting together late in the winter at such meetings as that of the North American Wildlife Conference, that might serve the purpose. But if we should again get into a tight situation with respect to waterfowl problems it might be necessary to get all the administrators together at some point.

I think it would be well, unless some member has questions to ask about the preliminary discussions that have taken place, all of which have been wholesome, to ask the Chairman of the Joint Committee on Time and Place to tell us something about their discussions, and then after the members of the group have expressed their views the Time and Place Committee may be in a position to make a final report and recommendation.

THE PRESIDENT: Will the Chairman of the joint committee please make the report?

MR. P. J. HOFFMASTER: Mr. President, the joint committee met yesterday afternoon for a couple of hours. You have already heard considerable discussion, so I will not attempt to review the arguments that were used in reaching our conclusions; I will present only the conclusions of the joint committee.

First, it was the consensus of opinion that the meetings should be held at a date later in the season than we are now meeting, preferably the first half of September—in other words, sometime between the first and the fifteenth of September.

The question of meeting at the same place year after year also was discussed at length. Again, it was the consensus of opinion that we should continue rotating our meetings from one place to another.

The committee does not feel that it should recommend a merging of the Society and the Association with other organizations.

The committee would like to have these matters discussed before it has a final meeting to decide on some of the questions with which it is charged, and for that reason I am simply giving you these tentative findings.

THE PRESIDENT: Is there any further discussion?

MR. SHAWHAN: Speaking for West Virginia, we would strongly advocate the holding down of the number of meetings. We would advocate a continuation of the rotation, and we would strongly endorse the suggestion that the meeting be held sometime during the month of September. It has certainly been made clear and emphasized to all the state administrators that time and money will permit only a certain amount of travel. If the continued attendance of state administrators is desired at these conventions, the number must be held down. Substantially West Virginia endorses the findings of the joint committee and advocates their adoption.

DR. LANGLOIS: The report of Mr. Hoffmaster certainly is in accord with my personal sentiments, as it is with the sentiments expressed by the membership of the American Fisheries Society in response to a questionnaire that was sent out a year ago. There is one point that I think needs to be discussed. This meeting that has been called by the head of the Biological Survey of all the commissioners has been called in June, and the commissioners have held their meeting at that time of the year in response to that request. This is a successful meeting, but the one at Mexico City was not so successful; certainly there was no increase in the membership as a result of that meeting. I believe the holding of meetings at such remote places, so far as the American Fisheries Society is concerned, works a definite hardship on the fish-culturists in particular and on the membership in general, because while the commissioners can vote their own expenses to attend a meeting at such a distance, the fish-culturists cannot do so. The entire Time and Place Committee of the American Fisheries Society at the Mexico City meeting consisted of commissioners, which put us entirely at a disadvantage.

I think we ought by all means to hold our meetings in conjunction with the International Association of Game, Fish and Conservation Commissioners; we need to have administrators present; we need to "sell our stuff" to them. But with the interests of the Society at heart I believe we ought to make a ruling that our Time and Place Committee should consist entirely of members who are not administrators. It seems to me to be the only way of avoiding the difficulties we have run into. I do not know just how that could be brought to pass. In any case, I offer the suggestion as a point for discussion.

MR. GORDON: You mean that the Time and Place Committee of the American Fisheries Society should consist of fisheries workers, while the Time and Place Committee of the International Association ought to be administrators?

DR. LANGLOIS: That is right.

MR. HERBERT C. DAVIS: I do not really believe that this matter requires any further discussion. I think we are all in complete agreement on the only two questions that are of importance, that is, whether the American Fisheries Society and the International Association shall continue to meet jointly, and whether they will return to their former practice of meeting in the early fall. I have not heard any dissension on these points.

I think it is well that those who perhaps have missed the last two meetings, as Dr. Langlois has pointed out, should understand definitely why the dates of meeting were changed, and I am going to mention it because I want you to keep it in mind in the future.

When it appeared to be necessary that the administrators meet with the representatives of the federal government, it became apparent that that would be the death knell of the International Association, because there would be no object at all in the same group of people meeting twice in the same year. The American Fisheries Society was courteous enough to go along with us to get the dates moved up to the month of June, for a period not to exceed two years. During this period I think we have convinced the federal government that if they want to meet the administrators of fish and game, they can come to where we meet. With all the experience the Biological Survey has had, they certainly can solve their problems in September with us as well as they can in June. The only question is, how many ducks? They have to count them in order to fix the bag limit, and that is the only thing they cannot fix in September. Let these two organizations meet in September, without considering any other organizations. Resist to the end any effort on the part of any federal agency to call any conference of administrators except at the time and place set by the American Fisheries Society and the International Association.

I think originally, as I have looked over some of the old memberships, they were drawn largely from our scientific institutions. But as conservation has grown your membership has come to include more and more men on our state payrolls, and if the interest of the administrators, of the states themselves, and of those public agencies which are going to have to pay the bill to get these fellows around, declines or is destroyed, or the organization is submerged in the interests of federal agencies, then the state will suffer. That is why I am happy to have found in the Time and Place Committee meeting yesterday an absolutely unanimous view that the two organizations should sit together and meet in the fall.

MR. HOFFMASTER: Mr. President, I should like to move, first, that the meetings in the future be held in the fall during the month of September, and second, that we continue to rotate these meetings among the provinces of Canada, the states of the United States, and the Republic of Mexico.

DR. PRITCHARD: As one of the few Canadian representatives present, it gives me much pleasure to second that motion.

THE PRESIDENT: The subject is open for discussion.

MR. GORDON: May I have just one word on this question of meeting in the month of September? You must be careful not to meet too late in September, because a great many of the members of the Society bring their families with them, and later in September the schools and colleges are open. Fisheries workers who are connected with educational institutions can attend during the first two weeks of September, but after that they are tied up with their college or university work. I would much rather see the date definitely limited to the first half of September if possible.

MR. HOFFMASTER: I have no objection to an amendment to that effect.

THE PRESIDENT: Will you so amend your motion, Mr. Hoffmaster?

MR. HOFFMASTER: Yes, I will amend it to read, the first half of September.

THE PRESIDENT: Does the person who seconded the motion accept the amendment?

DR. PRITCHARD: Yes.

(The motion was voted upon and carried.)

THE PRESIDENT: Do I hear a motion to continue the Time and Place Committee to confer with the committee of the International Association, with the understanding that the report of that joint committee shall be binding upon the Society, having in mind the motion which has just been passed?

MR. HERBERT C. DAVIS: I so move.

MR. BODE: I will second that.

(The motion was voted upon and carried.)

(EDITOR'S NOTE: At the concluding session of the convention of the International Association of Game, Fish and Conservation Commissioners on June 30, the joint Time and Place Committee's recommendation that the next meeting be held at Toronto, Canada, the International Association to hold its convention September 2 and 3, the conference of the U. S. Biological Survey with the state game administrators during the forenoon of September 4, and the conference of the U. S. Bureau of Fisheries with the state fish administrators during the afternoon of September 4, and the annual meeting of the American Fisheries Society September 5 and 6, was unanimously adopted.)

## AMENDMENT TO BY-LAWS

DR. LANGLOIS: In Article II of the Constitution and By-Laws there is a paragraph dealing with honorary and corresponding members. As it now stands it reads that the President of the United States, the Governors of the several states, the Secretary of Commerce of the United States, the Governor-General of Canada, the Lieutenant-Governors of the several Canadian provinces, and the Dominion Minister in charge of game and fisheries, shall be honorary members of this Society while occupying their respective official positions.

THE PRESIDENT: What about the President of Mexico?

DR. LANGLOIS: He is not included. In view of the fact that the U. S. Bureau of Fisheries is about to be transferred to the Department of the Interior, I move that the words "Secretary of Commerce" be struck out and the words "Secretary of the Interior" substituted in lieu thereof.

MR. GORDON: I will second the motion.

MR. HERBERT C. DAVIS: I would move an amendment that the President of Mexico be included.

THE PRESIDENT: There is an amendment offered that the President of Mexico be included. Is there a second to the amendment?

MR. CHALK: I will second the amendment.

(The amendment was voted upon and carried.)

THE PRESIDENT: The amendment includes the President of Mexico in the original motion, which we are now ready to deal with. Is there any further discussion or amendment?

(The motion as amended was voted upon and carried.)

## COMMITTEE ON NOMINATIONS

MR. FRED WESTERMAN: Your Committee on Nominations submits the names of the following members to serve as your officers for the ensuing year and recommends their election:

*Officers*

*President*, T. H. Langlois, Put-In-Bay, Ohio.
*First Vice-President*, James Brown, Frankfort, Kentucky.

*Second Vice-President,* John Van Oosten, Ann Arbor, Michigan.
*Secretary-Treasurer,* Seth Gordon, Harrisburg, Pennsylvania.
*Librarian,* Kenneth E. Cobb, Windsor Locks, Connecticut.

*Vice-Presidents of Divisions*

*Fish Culture,* M. C. James, Washington, D. C.
*Aquatic Biology and Physics,* A. R. Cahn, Norris, Tennessee.
*Commercial Fishing,* Herbert C. Davis, San Francisco, California.
*Protection and Legislation,* I. T. Quinn, Washington, D. C.
*Angling,* David H. Madsen, Salt Lake City, Utah.

*Committee on Foreign Relations*

A. G. Huntsman, *Chairman,* Toronto, Ontario.
Charles E. Jackson, Washington, D. C.
Señor Juan Zinser, Mexico City, Mexico.
William J. Tucker, Austin, Texas.
William C. Adams, Albany, New York.
B. O. Webster, Madison, Wisconsin.
B. M. Brennan, Seattle, Washington.

Your Nominations Committee gave considerable thought to the desirability of complying with the suggestion of the motion made yesterday afternoon to increase the membership of the Committee on Common and Scientific Names of Fishes to eight in order to give the membership a little better geographical distribution. However, upon referring to the by-laws of the Society, we find that the membership of that committee is limited to seven. We, therefore, considered some reorganization of the committee and wish to present the following list of names, two of which are new:

*Committee on Common and Scientific Names of Fishes*

Walter H. Chute, *Chairman,* Chicago, Illinois.
W. A. Clemens, Nanaimo, B. C., Canada.
James Nelson Gowanloch, New Orleans, Louisiana.
Samuel F. Hildebrand, Washington, D. C.
Carl L. Hubbs, Ann Arbor, Michigan.
George S. Myers, Stanford University, California.
Leonard P. Schultz, Washington, D. C.

I would like to move, Mr. President, the election of these officers and standing committees for the ensuing year.

THE PRESIDENT: You have heard the report of the Nominating Committee and the motion for its adoption. Are there any further nominations? There being no further nominations, is there a second to the motion?

MR. ALDRICH: I will second it.

THE PRESIDENT: It has been moved and seconded that the recommendations of the committee be accepted and their nominees be elected by the Society.

(The motion was voted upon and carried.)

THE RETIRING PRESIDENT: I will ask Mr. Donaldson and Mr. Wales to escort the newly elected President to the Chair.

(The President-Elect was conducted to the rostrum.)

THE RETIRING PRESIDENT: Dr. Langlois, I want to congratulate you on the honor which has been bestowed upon you. I commend the Society upon its selection. I am sure the Society is in the very best of hands in the selection which has

been made of the officers for the ensuing year. I thank the committees who have served so faithfully and the members who have made this meeting a success.

(The President-Elect took the Chair.)

THE PRESIDENT-ELECT: Thank you, Mr. Foster. I do not know that any speech is called for. I simply want to say that I have endeavored to further the interests of the American Fisheries Society for the last fifteen years, and shall continue to do so.

Is there any further business before we adjourn?

MR. WESTERMAN: I think this body should extend a vote of thanks to the retiring President who has so faithfully served us during the past year and in the meeting which is about to be concluded. I move, sir, that we tender a rising vote of thanks to the retiring President, Mr. Fred J. Foster, of Washington.

MR. WALES: I will second the motion.

(The motion was carried by rising vote, with applause.)

THE PRESIDENT-ELECT: I will entertain a motion to adjourn.

MR. HOFFMASTER: I move that we adjourn.

(The motion was seconded and agreed to, and the meeting adjourned.)

# In Memoriam

Dr. George C. Embody, Ithaca, New York

Earl E. Hoover, Concord, New Hampshire

W. M. Keil, Asheville, North Carolina

Dr. William C. Kendall, Freeport, Maine

# PART II

# PAPERS AND DISCUSSIONS

# TAGGING EXPERIMENTS WITH LAKE TROUT, WHITEFISH, AND OTHER SPECIES OF FISH FROM LAKE MICHIGAN[1]

OLIVER H. SMITH

*Smith Brothers, Port Washington, Wisconsin*

AND

JOHN VAN OOSTEN

*U. S. Bureau of Fisheries, Ann Arbor, Michigan*

## ABSTRACT

A total of 2,902 Lake Michigan fish was tagged and released, 48.8 per cent of which were lake trout and 85 per cent lake trout, lake herring, and whitefish. A total of 388 fish or 13.4 per cent was recaptured. The percentages of returns indicated a tremendous fishing intensity for lake trout, whitefish, and sturgeon. About 81 per cent of the recaptured fish were retaken within a radius of 25 miles from the port of tagging (Port Washington, Wisconsin). Lake trout, rainbow trout, and sturgeon were found to be extensive travelers; lake herring, whitefish, chubs, pilots, and perhaps perch did not migrate so extensively. Lake trout, herring, and whitefish tended to move in a northerly direction, perch in a southerly, and rainbow trout in an easterly, toward the Michigan shore. Sturgeon apparently roam all over the lake. Fifty-three per cent of the recovered lake trout were recaptured within one year of release, 73 per cent within 25 miles from Port Washington. It required three years for the trout to become fairly well scattered throughout the lake. With the attainment of adulthood lake trout moved in all directions from the port of release, although nearly 50 per cent of the adults were retaken within 25 miles from this port. Fish moved across state boundaries. Data are given on the growth and estimated age of the tagged lake trout, rainbow trout, whitefish, and sturgeon. The minimum size limits of lake trout and whitefish on the Great Lakes are economically unsound—they are too low—because they permit the capture of these species at a time of most rapid increase in weight.

## INTRODUCTION

The first record of an attempt to tag fish on the Great Lakes was reported by Milner (1874) who wrote, "In order to obtain a definite knowledge of their habits in this particular, metal tags, with numbers indicating the locality, were distributed to fishermen at twenty points along the lake [Lake Michigan], to be fastened to the fins of live fish, which were then to be released . . . . It is thought that but few of them

[1]Published with the permission of the Commissioner of Fisheries. This paper is written in commemoration of the late Mr. Lester Smith (brother of the senior author), Port Washington, Wisconsin, who inaugurated and directed the tagging experiments on Lake Michigan and who devoted much of his time and energy to the completion of these experiments. Mr. Smith, who was one of the most progressive, broad-minded, and far-sighted commercial fishermen on the Great Lakes, had an intense interest in all scientific work pertaining to the fisheries. The entire cost of the experiments was borne by his firm, the Smith Brothers. The outlay of large sums of money for tagging operations and the release of many marketable fish during these operations reveal the progressive spirit and self-sacrifice of the Smith brothers—a sacrifice unparalleled among the fishermen on the Great Lakes.—J. V. O.

were used. A similar proceeding was afterward carried out by Mr. George Clark, of Ecorse, on the Detroit River, but none of the fish were ever heard from."

Cole (1905) tagged and liberated about one hundred carp in the vicinity of Port Clinton and Sandusky on Lake Erie, but none of these fish was ever heard from again. "A small copper tag bearing a number was attached, usually to the strong spine of the dorsal fin, by a piece of copper wire, though in a few cases the wire was passed through the basal lobe of one of the pectoral fins."

The Game and Fisheries Department of Ontario (1930) reported the tagging of 635 fish on Lake Erie, including steelhead trout, whitefish, herring, white bass, yellow pickerel, blue pickerel, and smallmouth black bass. A few returns have been made, but no report on the results has been published.

Snyder (1932) tagged 150 smallmouth black bass on Lake Ontario in July, 1931, and reported the recapture of twelve in 1931 and seven in 1932. None of the nineteen bass was retaken more than 3 miles from the point of release. In July, 1932, 350 smallmouth bass were tagged and released, of which twenty-two were recaptured. Five of the recaptured fish were taken from 5 to 9 miles from the point of release, one was taken at a distance greater than 9 miles, and the remaining sixteen were recovered at a distance less than 5 miles.

At the insistence of the junior author (Van Oosten), Lester Smith (1933) made a preliminary report on his tagging experiment with the Lake Michigan fish. He outlined briefly the development of his work—its objectives and methods—and presented some of the more interesting individual records of migration. No attempt was made to summarize the data in tabular form and to analyze and correlate the various results derived from them.

An interesting news item in *The Fisherman* of July, 1933, reported the identification of a 75-pound, branded sturgeon captured in the spring of 1933 at the dam at Newaygo, Michigan. The number "41" was branded on the fish's side. It was learned that this individual had been marked about twenty-eight years previously at Anchor Bay in Lake St. Clair when it weighed 41 pounds. This sturgeon had added 34 pounds to its weight in twenty-eight years, and had migrated from Lake St. Clair to Newaygo via Muskegon on Lake Michigan.

During the fall of 1935, 650 lake trout were tagged and liberated in Green Bay by the Wisconsin Conservation Department, and approximately 150 were tagged in Lake Michigan (Schneberger, 1936). Thirteen trout, all tagged in Green Bay, were recaptured, all but one (taken at Algoma, Wisconsin) being retaken in Green Bay waters. Four of the returns came from Michigan fishermen.

Shetter (1938a) brought up to date the record of recaptures of rainbow or steelhead trout tagged in Michigan streams (Little Manistee and Big Manistee) and by Smith Brothers at Port Washington, Wisconsin. Thirteen returns were made from Lake Michigan.

On November 7, 1938, the Michigan Institute for Fisheries Research tagged twenty-eight lake trout about ¾ mile WNW by W of Seven-Mile Point in Lake Michigan (Shetter, 1938b). Two of these tagged fish were recovered a year later in November, 1939, about 5 miles north of the place of tagging.

## Methods

Since Smith (1933) has already described in detail the history, objectives, and methods of the tagging operations reported in the present paper, it is only necessary to repeat here sufficient details for a proper understanding of the work. Systematic tagging was begun on June 20, 1929, and continued until August 4, 1931, during which period 2,902 (including second releases) Lake Michigan fish were tagged, most of which were undersized lake trout (*Cristivomer n. namaycush*) and whitefish (*Coregonus clupeaformis*). Virtually all of the tagging was done during the summer months (June 20 to September 23, 1929; June 2 to August 25, 1930; June 5 to August 4, 1931). Occasional specimens were marked at other times of the year. All of the tagged fish were caught in pound nets operated by Smith Brothers at Port Washington, Wisconsin.[2] Three sizes of the metal strap tags (U-shaped) were used. The largest size (No. 1), made of aluminum, was about 1 inch long and was employed for sturgeon (*Acipenser fulvescens*) and large trout. The medium-sized tag (No. 2), ¾ inch long, was made of non-corrosive metal and was used for the medium-sized fish, whereas the small-sized tag (No. 3), about ½ inch long, also made of non-corrosive metal, was used for tagging all undersized trout and whitefish, herring (*Leucichthys artedi*), chubs (*Leucichthys* spp.), perch (*Perca flavescens*) and the other small varieties of fish. All tags were stamped with the name, S. Bros., and a number. During the first year of the experiments all tags were attached to the caudal fin; thereafter they were clamped onto the gill cover. No reward was offered for the return of the tags.

## Percentage of Recaptures and Length at Tagging

Table 1 shows the number of fish tagged by Smith Brothers at Port Washington, Wisconsin, in each year and in all years combined, and the number and percentage of recaptures.[3] A total of 2,902 fish was tagged, of which 388 or 13.4 per cent were recaptured. The totals for tagged fish include the number of individuals that were recaptured and released a second time. Similarly, the totals for recaptured fish include the number of individuals that were recovered twice (whitefish 3, lake trout 2, sturgeon 1). The average percentage of

[2]In addition to the fish tagged by Smith Brothers, 99 were marked by DeWitt Brothers at Oostburg, Wisconsin, during July 21 to August 24, 1931, and 150 (mostly adult lake trout) were tagged by Clifford Wenniger, at Bailey's Harbor, Wisconsin, on October 16, 1934, during the closed season. Only one (tagged at Bailey's Harbor) of these fish was recaptured. It was a trout taken in a pound net at Escanaba, Michigan, on May 25, 1935, at a length of 19 inches and a weight of 2 pounds dressed.

[3]We are indebted to Dr. Ralph Hile for assistance in the compilation of the tables and to Dr. H. J. Deason for the preparation of the map.

TABLE 1. NUMBER OF FISH TAGGED IN EACH YEAR AND IN ALL YEARS COMBINED, AND THE NUMBER AND PERCENTAGE OF RECAPTURES

| Year | Item | Species | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lake trout | Lake herring | White-fish | Rain-bow trout | Perch | Chubs | Pilots | Law-yers | Stur-geon | Carp | All species[1] |
| 1929 | Number tagged | 169 | 115 | 36 | 35 | 34 | 26 | 3 | 8 | 1 | 1 | 430 |
| | Number of recaptures | 18 | 2 | 4 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 31 |
| | Percentage recaptured | 10.7 | 1.7 | 11.1 | 8.6 | 11.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.2 |
| 1930 | Number tagged | 236 | 28 | 172 | 35 | 23 | 24 | 8 | 4 | 1 | -- | 533 |
| | Number of recaptures | 36 | 0 | 45 | 4 | 3 | 0 | 4 | 0 | 1 | -- | 93 |
| | Percentage recaptured | 15.3 | 0.0 | 26.2 | 11.4 | 13.0 | 0.0 | 50.0 | 0.0 | 100.0 | -- | 17.4 |
| 1931 | Number tagged | 1,011 | 450 | 249 | 77 | 65 | 56 | 24 | 4 | 2 | 1 | 1,939 |
| | Number of recaptures | 164 | 30 | 52 | 2 | 3 | 6 | 3 | 1 | 2 | 1 | 264 |
| | Percentage recaptured | 16.2 | 6.7 | 20.9 | 2.6 | 4.6 | 10.7 | 12.5 | 25.0 | 100.0 | 100.0 | 13.6 |
| 1929, 1930 and 1931 | Number tagged | 1,416 | 593 | 457 | 147 | 122 | 106 | 35 | 16 | 4 | 2 | 2,902 |
| | Number of recaptures | 218 | 32 | 101 | 9 | 10 | 6 | 7 | 1 | 3 | 1 | 388 |
| | Percentage recaptured | 15.4 | 5.4 | 22.1 | 6.1 | 8.2 | 5.7 | 20.0 | 6.2 | 75.0 | 50.0 | 13.4 |

[1]Includes one buffalo and one shiner, tagged in 1929; two suckers, tagged in 1930. No recaptures were made of these fish.

recoveries was the smallest (7.2) for the 1929 specimens. This low percentage may have been due in part to the fact that the tags were attached to the caudal fin of these fish instead of to the operculum. Then, too, the tagging technique improved with experience and the experiment may not have been as well advertised in 1929 as in later years, so that proportionately fewer tags were returned by the fishermen at the beginning of the experiment. Lake trout comprised 48.8 per cent of the fish tagged and lake trout, lake herring, and whitefish composed 85.0 per cent of the total. The percentage of returns varied from 5.4 for the lake herring to 75.0 for the sturgeon. A surprisingly high percentage of returns (22.1) was obtained for the whitefish, which percentage exceeded that of the lake trout (15.4).

The percentages of returns for the lake trout, whitefish, and sturgeon suggest a tremendous fishing intensity in Lake Michigan. Experiments by Snyder (1932), Markus (1933), and Shetter (1936) showed that 40 to 50 per cent of the fish lose their tags within a period of one month to one year. Since 52 per cent of the tagged Lake Michigan fish were recaptured after one month and 30 per cent after one year, it may be conservatively estimated that in general at least 50 per cent of the fish had lost their tags. Consequently, in a determination of fishing intensity it must be assumed that the original population is represented by one-half of the number of fish tagged. On this basis, computations show that at least 31 per cent of the lake trout that had reached an average length of 12.8 inches (Table 2) and 44 per cent of the whitefish that had attained an average length of 11.8 inches were subsequently taken by the commercial fishermen. A total of five sturgeon (see footnote 4, page 71, for the record of the sturgeon not included in Table 1) was tagged and four of them (80 per cent) were retaken. These minimum percentages of recovery indicate that the grounds occupied by the fish are very well covered by the fishermen. The percentages take on added significance when it is remembered that factors other than the loss of tags enter into the computations. Such factors include the failure of the fishermen to report all recaptured fish, the mortality due to the tagging or to natural causes, and possibly the incompleteness of the experiment since it is probable that additional returns will come in, for it is known that many lake trout more than 6 pounds in weight occur in the lake and yet only three of such size have been recaptured up to the present time. The data show that more than 31 per cent of the lake trout and more than 44 per cent of the whitefish of the sizes tagged later entered the commercial nets. About 28 per cent of these recaptured trout were of legal size at the time of the experiments (12 inches), but only about 14 per cent of the whitefish were of such size (13 inches).

The average total length and range in length in inches of the fish at tagging are given in Table 2. Most of the individuals were young fish. A compilation of the average lengths and ranges in lengths at tagging of the recaptured fish indicated no important differences in

TABLE 2. AVERAGE TOTAL LENGTH AND RANGE IN LENGTH IN INCHES OF THE FISH AT TAGGING

| Item | Species[1] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lake trout | Lake herring | Whitefish | Rainbow trout | Perch | Chubs | Pilots | Lawyers | Sturgeon | Carp |
| Average length | 12.8 | 10.7 | 11.8 | 17.1 | 7.4 | 8.3 | 12.5 | 16.9 | 24.8 | 24.0 |
| Range in length | 6-17 | 6-16 | 6-16 | 6-30 | 5-13.5 | 6-12.5 | 11-15 | 11-27 | 21-32 | 24 |

[1]In addition there were tagged: one buffalo—12 inches; two suckers—16 and 20 inches; one shiner—5 inches.

TABLE 3. NUMBER AND PERCENTAGE OF TAGGED FISH RECAPTURED AT VARIOUS DISTANCES FROM PORT WASHINGTON, WISCONSIN, OR THE POINT OF TAGGING

| Distance in miles between points of tagging and recapture | Species | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lake trout | Lake herring | Whitefish | Rainbow trout | Perch | Chubs | Pilots | Lawyers | Sturgeon | Carp | All species |
| 1 to 10 | 85 | 22 | 68 | 4 | 6 | 6 | 7 | -- | 1 | -- | 199 |
| | (39.0) | (68.8) | (67.3) | (44.4) | (60.0) | (100.0) | (100.0) | -- | (33.3) | | (51.3) |
| 11 to 25 | 74 | 9 | 29 | 1 | 2 | -- | -- | -- | -- | 1 | 116 |
| | (34.0) | (28.1) | (28.7) | (11.1) | (20.0) | -- | -- | -- | -- | (100.0) | (29.9) |
| 26 to 50 | 10 | 1 | 1 | -- | 1 | -- | -- | 1 | -- | -- | 14 |
| | (4.6) | (3.1) | (1.0) | | (10.0) | -- | -- | (100.0) | -- | -- | (3.6) |
| 51 to 75 | 20 | -- | 3 | 1 | 1 | -- | -- | -- | -- | -- | 25 |
| | (9.2) | -- | (3.0) | (11.1) | (10.0) | -- | -- | -- | -- | -- | (6.4) |
| 76 to 100 | 13 | -- | -- | 1 | -- | -- | -- | -- | -- | -- | 14 |
| | (5.9) | -- | -- | (11.1) | -- | -- | -- | -- | -- | -- | (3.6) |
| 101 to 125 | 12 | -- | -- | 2 | -- | -- | -- | -- | 1 | -- | 15 |
| | (5.5) | -- | -- | (22.2) | -- | -- | -- | -- | (33.3) | -- | (3.9) |
| 126 to 150 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 |
| | (0.9) | -- | -- | -- | -- | -- | -- | -- | -- | -- | (0.5) |
| 151 to 225 | 2 | -- | -- | -- | -- | -- | -- | -- | 1 | -- | 3 |
| | (0.9) | -- | -- | -- | -- | -- | -- | -- | (33.3) | -- | (0.8) |
| Total | 218 | 32 | 101 | 9 | 10 | 6 | 7 | 1 | 3 | 1 | 388 |

lengths from those shown in the table. It appears, then, that the smaller individuals of a species retained their tags as well as did the larger ones.

## Distances Travelled, Periods of Freedom, and Direction of Migration

The number and percentage of tagged fish recaptured at various distances are presented in Table 3. It may be seen that 51.3 per cent of the recovered fish were taken 10 miles or less from Port Washington, Wisconsin, and 81.2 per cent were taken within a radius of 25 miles from this port. No exact location was given for many of the fish taken outside of the 25-mile zone. These fish were credited to the port where the fisherman who made the returns operated and as a rule to the zone in which the port is located. It is not always possible, therefore, to state specifically the minimum distance travelled by a fish, and hence the distances are recorded by zones. The data of Table 3 suggest that, in contrast to the lake trout, rainbow trout (*Salmo gairdnerii irideus*), and sturgeon, the lake herring, whitefish, chubs, pilots (*Prosopium quadrilaterale*), and perhaps perch were not extensive travelers, nearly all of them having been retaken within 25 miles from the point of release. Even the majority of the lake trout (73 per cent) and rainbow trout (56 per cent) was recaptured within this distance. All of the fish were retaken in Lake Michigan or its tributaries.

There is no doubt some relationship between distance travelled and the period of freedom of the fish. Table 4 has been constructed to show the number and percentage of tagged fish recaptured after different periods of time. In Table 5 are given the greatest distances travelled by the various species, measured in as nearly a straight line as possible from Port Washington to the locality of recapture, and the time between tagging and recapture. Table 4 shows that about 33 per cent of all species were retaken within ten days after tagging, 48 per cent within thirty days, and 57 per cent within sixty days. Virtually all of the chubs and pilots were recovered within twenty days after release and nearly all of the perch and lake herring within sixty days. It is possible, therefore, that these short periods of freedom may account for the short distances travelled by the recaptured individuals of these species. Table 3 shows that the chubs and pilots were recovered within 10 miles, and nearly all the perch and herring within 25 miles from Port Washington, although the lake trout retaken after corresponding periods of freedom had travelled greater distances (1-25 and 1-50 miles; Table 6). One pilot that had been out nearly eight months was recaptured within a radius of 10 miles from Port Washington.

All of the herring were recaptured to the north of Port Washington, one individual having been retaken at Two Rivers, Wisconsin, about 55 miles distant, one month and two days after release (Table

**TABLE 4. NUMBER AND PERCENTAGE OF TAGGED FISH RECAPTURED AFTER DIFFERENT PERIODS OF TIME[1]**

| Time between tagging and recapture | Species | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lake trout | Lake herring | Whitefish | Rainbow trout | Perch | Chubs | Pilots | Lawyers | Sturgeon | Carp | All species |
| 1 to 10 days | 46 (21.4) | 22 (68.8) | 41 (40.6) | 5 (55.6) | 1 (11.1) | 4 (66.7) | 4 (57.1) | -- | 1 (33.3) | 1 (100.0) | 125 (32.6) |
| 11 to 20 days | 14 (6.5) | 4 (12.5) | 8 (7.9) | 1 (11.1) | 3 (33.3) | 1 (16.7) | 2 (28.6) | -- | -- | -- | 33 (8.6) |
| 21 to 30 days | 9 (4.2) | 2 (6.2) | 11 (10.9) | -- | 2 (22.2) | 1 (16.7) | -- | -- | -- | -- | 25 (6.5) |
| 1 to 2 months | 14 (6.5) | 3 (9.4) | 15 (14.9) | -- | 2 (22.2) | -- | -- | -- | -- | -- | 34 (8.9) |
| 2 to 3 months | 4 (1.9) | 1 (3.1) | 7 (6.9) | -- | -- | -- | -- | -- | -- | -- | 12 (3.1) |
| 3 to 6 months | 10 (4.7) | -- | 1 (1.0) | -- | -- | -- | -- | 1 (100.0) | -- | -- | 12 (3.1) |
| 6 to 9 months | 5 (2.3) | -- | -- | -- | -- | -- | 1 (14.3) | -- | 1 (33.3) | -- | 7 (1.8) |
| 9 to 12 months | 12 (5.6) | -- | 6 (5.9) | 3 (33.3) | 1 (11.1) | -- | -- | -- | -- | -- | 22 (5.7) |
| 1 to 2 years | 42 (19.5) | -- | 7 (6.9) | -- | -- | -- | -- | -- | -- | -- | 49 (12.8) |
| 2 to 3 years | 29 (13.5) | -- | 3 (3.0) | -- | -- | -- | -- | -- | -- | -- | 32 (8.3) |
| 3 to 4 years | 14 (6.5) | -- | 2 (2.0) | -- | -- | -- | -- | -- | 1 (33.3) | -- | 17 (4.4) |
| 4 to 5 years | 8 (3.7) | -- | -- | -- | -- | -- | -- | -- | -- | -- | 8 (2.1) |
| 5 to 6 years | 5 (2.3) | -- | -- | -- | -- | -- | -- | -- | -- | -- | 5 (1.3) |
| 6 to 7 years | 2 (0.9) | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 (0.5) |
| 7 to 8 years | 1 (0.5) | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 (0.3) |
| Total | 215 | 32 | 101 | 9 | 9 | 6 | 7 | 1 | 3 | 1 | 384 |

[1]Data on time lacking for three trout and one perch.

TABLE 5. GREATEST DISTANCES TRAVELLED BY THE VARIOUS SPECIES, MEASURED AS NEARLY AS POSSIBLE IN A STRAIGHT LINE FROM PORT WASHINGTON, WISCONSIN, TO THE LOCALITY OF RECAPTURE

| Species | Locality of recapture | Minimum distance in miles | Time between tagging and recapture | | | Average number of miles per day out |
|---|---|---|---|---|---|---|
| | | | Year | Month | Days | |
| Lawyer | Sheboygan, Wis. | 27 | 0 | 5 | 26 | 0.2 |
| Perch | Sheboygan, Wis. | 27 | 0 | 1 | 17 | 0.6 |
| Perch | Kenosha, Wis. | 57 | 0 | 9 | 2 | 0.2 |
| Herring | Two Rivers, Wis. | 55 | 0 | 1 | 2 | 1.7 |
| Whitefish | Two Rivers, Wis. | 55 | 0 | 1 | 22 | 1.1 |
| Whitefish | Two Rivers, Wis. | 55 | 3 | 2 | 5 | 0.1 |
| Whitefish | Waukegan, Ill. | 72 | 0 | 11 | 27 | 0.2 |
| Rainbow trout | Grand Haven, Mich. | 81 | 0 | 0 | 7 | 11.6 |
| Rainbow trout | Manistee River, Mich. | 112 | 0 | 9 | 2 | 0.4 |
| Rainbow trout | Manistee River, Mich. | 120 | 0 | 9 | 22 | 0.4 |
| Sturgeon | Michigan City, Ind. | 117 | 3 | 4 | 25 | 0.1 |
| Sturgeon[1] | Fayette, Mich. | 154 | 0 | 8 | 8 | 0.7 |
| Lake trout | Washington Isl., Wis. | 139 | 3 | 6 | 28 | 0.1 |
| Lake trout | Washington Isl., Wis. | 139 | 4 | 4 | 22 | 0.1 |
| Lake trout | Seul Choix, Mich. | 195 | 6 | 10 | 27 | 0.1 |
| Lake trout | St. Ignace, Mich. | 225 | 3 | 0 | 29 | 0.2 |

[1]Tagged at Oostburg, Wisconsin, by DeWitt Bros.

5). Three of the nine recaptured perch travelled south to Milwaukee and Kenosha, Wisconsin, the Kenosha individual having travelled at least 57 miles during the nine months of freedom (Table 5), while five individuals were caught at Port Washington and one to the north at Sheboygan, Wisconsin, about 27 miles distant (Table 5). All of the chubs and pilots were retaken at Port Washington. The one lawyer (*Lota maculosa*) was recovered at Sheboygan (Table 5), and the carp (*Cyprinus carpio*) at Cedar Grove, about 15 miles north of Port Washington. Four of the nine recaptured rainbow trout were taken in Michigan [Grand Haven, Muskegon, Manistee River (2)], four at Port Washington, and one to the north at Oostburg. The sturgeon that had been out about three years and five months was caught at Michigan City, Indiana, approximately 117 miles from the point of release. The other sturgeon, tagged at Oostburg, Wisconsin, was retaken at Sheboygan, released and again taken at Fayette, Michigan, about 154 miles from the place of tagging (Table 5).[4]

Fifty-nine per cent of the tagged whitefish were retaken within thirty days after release and 74 per cent within sixty days (Table 4). Most of the recaptured whitefish, therefore, did not have time to travel very far. However, even those individuals that did have sufficient time did not move great distances, which fact indicates that the whitefish is not an extensive traveler. Two of the seven individuals that had been out from one to two years were taken at Oostburg, 19 miles north of Port Washington; the remaining five were recaptured at Port Washington. However, none of the recaptured whitefish that had been out more than two years was caught at Port Washington, but all

[4]For the sake of completeness it may be recorded here that Smith (1933) reported the recapture of a sturgeon at Indiana Harbor, Indiana, one year after its release at Port Washington. This fish was marked about 1927 with a numbered silver tag made by a local jeweler.

were taken to the north at Cedar Grove (2), Oostburg (2), and Two Rivers (1) at distances that varied from 15 to 55 miles (Table 5). All but four of the 101 recaptured whitefish were taken within 25 miles from Port Washington (Table 3).

There appeared to be no correlation between distances travelled by the whitefish and time out. For example, the individual that covered the greatest distance (72 miles to Waukegan, Illinois) had been free for about one year, whereas the fish that had been out the longest (three years, nine months, twenty-one days) was retaken at Cedar Grove, 15 miles distant. The two fish that reached Two Rivers, 55 miles distant, had been out respectively, one month, twenty-two days and three years, two months, five days (Table 5). Only one tagged whitefish was retaken south of Port Washington (Waukegan, Illinois); all others were caught either at the port of tagging or to the north within a distance of 55 miles (Two Rivers). Undoubtedly the whitefish is a non-migratory species.

The data presented so far indicate that if the fish migrate at all, the herring and whitefish tend to go in a northerly direction from Port Washington, at least as far as Two Rivers, the perch in a southerly direction, at least as far as Kenosha, and the rainbow trout to the east to the Michigan shore. Too few data are available for the chubs, pilots, lawyer, and carp for reliable conclusions, although the one eight-month record of the pilot indicates that this species is non-migratory like its relatives, the herring and whitefish, and the single records for the lawyer and carp suggest that these species move in a northerly direction. The sturgeon apparently roam all over the lake. Table 5 indicates that the rainbow trout are the fast travelers in Lake Michigan, no doubt due to the fact that most of them must return each year to their spawning grounds in Michigan streams.

*Lake trout*—It has already been indicated that the lake trout were extensive travelers in Lake Michigan. Since more data have been collected for this species than for the others, a more detailed discussion is possible for the lake trout than for the other varieties. The discussion that follows is based on Tables 3 to 7, inclusive. Table 4 shows that 21 per cent of the tagged lake trout were retaken within ten days, 39 per cent within two months, and 53 per cent within one year of release. Seventy-three per cent of the lake trout were recaptured within 25 miles from Port Washington (Table 3).

Table 6 shows the relationship between the period of freedom of lake trout after tagging and the distance of the region of recapture from the locality of tagging. It may be seen that some correlation exists between distance covered and period of freedom. Only one of the sixty-nine trout that were recaptured within thirty days had travelled more than 25 miles. The fish that were out from one to two months had extended the range to 50 miles, whereas those that were out from two to twelve months had added another 25 miles to the range. The trout that were out from one to three years had travelled

**TABLE 6. RELATIONSHIP BETWEEN THE PERIOD OF FREEDOM OF LAKE TROUT AFTER TAGGING AND THE DISTANCE OF THE REGION OF RECAPTURE FROM THE LOCALITY OF TAGGING**

| | Number of fish recaptured at various distances from Port Washington, Wisconsin, or the point of tagging | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time between tagging and recapture** | **1 to 10 miles** | **11 to 25 miles** | **26 to 50 miles** | **51 to 75 miles** | **76 to 100 miles** | **101 to 125 miles** | **126 to 150 miles** | **151 to 225 miles** | **Total number** |
| 1 to 10 days | 37 | 9 | -- | | -- | -- | -- | -- | 46 |
| 11 to 20 days | 7 | 6 | -- | 1 | -- | -- | -- | -- | 14 |
| 21 to 30 days | 3 | 6 | -- | -- | -- | -- | -- | -- | 9 |
| 1 to 2 months | 8 | 3 | 3 | -- | -- | -- | -- | -- | 14 |
| 2 to 3 months | 3 | -- | -- | 1 | -- | -- | -- | -- | 4 |
| 3 to 6 months | 5 | | -- | 4 | 1 | -- | -- | -- | 10 |
| 6 to 9 months | 3 | 1 | -- | 1 | -- | -- | -- | -- | 5 |
| 9 to 12 months | 2 | 7 | -- | 3 | -- | -- | -- | -- | 12 |
| 1 to 2 years | 12 | 20 | 1 | 5 | -- | 4 | -- | -- | 42 |
| 2 to 3 years | 3 | 14 | 2 | 3 | 4 | 3 | -- | -- | 29 |
| 3 to 4 years | 1 | 4 | 1 | 1 | 3 | 2 | 1 | 1 | 14 |
| 4 to 5 years | 1 | 1 | 2 | 1 | 2 | -- | 1 | -- | 8 |
| 5 to 6 years | -- | -- | -- | -- | 2 | 3 | -- | -- | 5 |
| 6 to 7 years | -- | -- | 1 | -- | | -- | -- | 1 | 2 |
| 7 to 8 years | -- | -- | -- | -- | 1 | -- | -- | -- | 1 |
| Total | 85 | [1]71 | 10 | 20 | 13 | 12 | 2 | 2 | 215 |

[1]Data on time lacking for three trout.

as far as the 125-mile limit, whereas all of those that had moved beyond this limit had been at liberty more than three years.

Although there was some correlation between distance and time, this relationship does not mean necessarily that the longer the trout were out the farther they had travelled from Port Washington. Table 6 shows clearly that up to about three years of freedom most of the recovered tagged trout were recaptured within 25 miles from Port Washington. Thereafter the trout had become fairly well scattered throughout all of the zones, as is indicated by the following distribution among the eight zones, beginning with the first one: 2, 5, 4, 2, 8, 5, 2, 2.

It may be difficult to determine with certainty the general direction of migration of the lake trout (and other species), since the localities of the recaptures may have depended more on the distribution of the fishermen and fishing gear or on the cooperation of the fishermen than on the movements of the fish themselves. However, it is believed that the data in general indicate the real trend of direction. Figure 1 shows the approximate localities where the lake trout were recovered. The concentric arcs, 10, 25, 50, etc., denote miles from Port Washington. The number under the name of a port represents the total number of tagged trout taken by the fishermen operating out of that port. The encircled numbers represent the number of tagged trout caught in that general area, and the black dots show the localities of recovery of the individual fish for which exact data were available. Figure 1 suggests that the lake trout tended to move in a northerly direction from Port Washington following the Wisconsin shore. Only nineteen trout were recovered to the south of Port Washington (seventeen along the west shore) and 133, excluding the seventy-three taken off Oostburg,

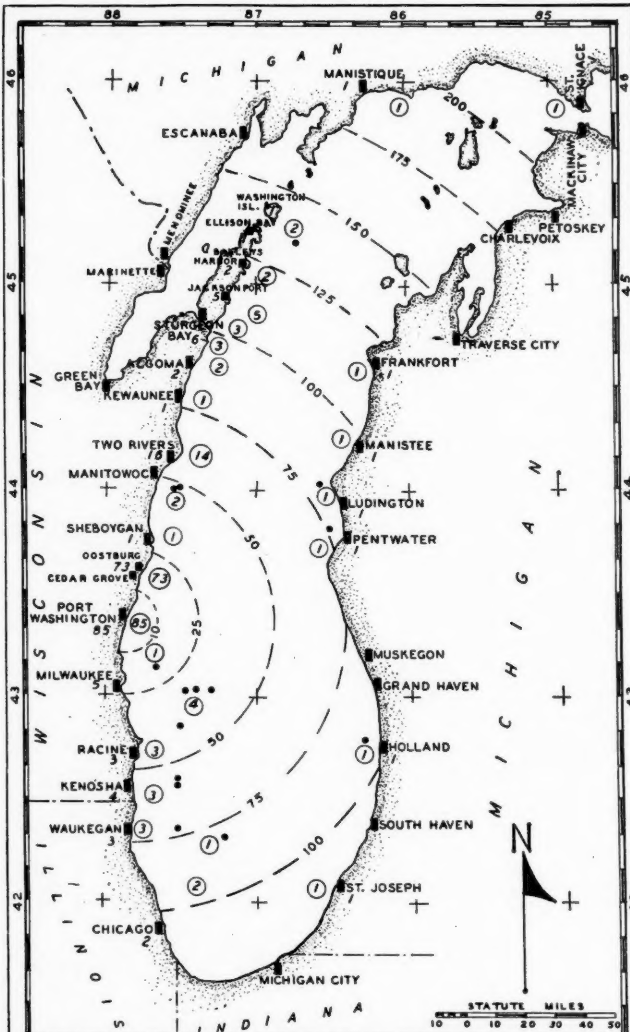


Figure 1.—Map of Lake Michigan showing localities of recaptures of lake trout (for explanation see text).

to the north (127 along the west shore). Only eight of the 218 recaptured trout were taken out of eight Michigan ports. These eight fish had been out for periods that ranged from about one year, eight and one-half months to six years, eleven months. The fact that these trout were taken at nearly every important port along the north and east shores indicates that if given time enough the Wisconsin lake trout become widely distributed throughout Lake Michigan. Six tagged lake trout were recovered in Illinois waters. No doubt the trout hatched in the Illinois, Indiana, and Michigan waters of Lake Michigan likewise migrate beyond the borders of their home state.

The question arises, "Did the trout scatter in all directions from Port Washington or did they follow the shore line?" The fact that no small trout were recovered in Michigan (outside the 50-mile zone) but that four were taken beyond this zone to the south of Kenosha and five to the north of Manitowoc (one of which was taken beyond the 75-mile radius off Algoma), suggests that the small fish moved along the western coast. That the baby trout populations of the east and west shores do not mingle to any considerable extent was also indicated by the U. S. Bureau of Fisheries' experiments with chub nets in which it was found that these small fish were 2.7 times as abundant in the Michigan waters as in the Wisconsin waters of Lake Michigan (Van Oosten, 1933). Apparently the Port Washington trout reached the east shore only as adults.

Did these adult fish cross the lake, follow the shore line, or scatter in all directions? The fact that the records of recaptures were fairly well distributed along the entire shore line (except for the region between Frankfort and Mackinaw City, Michigan; see Figure 1) suggests that the trout might have followed the south and north shores to reach Michigan waters. If these routes were followed we would expect, all other things being equal, that the Michigan fish required more time than the Wisconsin trout to traverse a certain distance from Port Washington. The records show that the first recapture of an adult lake trout from the 75- to 100-mile zone was made in Wisconsin after two years, two months, twenty-three days; in Illinois after two years, seven months, ten days; and in Michigan after two years, one month, seventeen days. The first return from the 100- to 125-mile zone was made in Wisconsin after one year, four months, twenty days; and in Michigan after one year, eight months, nineteen days; from the 126- to 150-mile zone in Wisconsin after three years, six months, twenty-eight days; and from the 176- to 225-mile zone in Michigan after three years, twenty-nine days. Records of other recaptures from these zones likewise indicate that the time between release and recapture was about the same for corresponding distances, irrespective of the direction of travel. These data suggest that the adult trout tended to scatter in all directions from Port Washington, although most of the long-distance travelers moved to the north (Table 7). All of the lake trout recaptured beyond the 75-mile limit were adults, except one;

seventeen of these adults were taken in northern Wisconsin, three in Illinois, and eight in Michigan, of which last group six were recovered to the north and two to the south of Port Washington (Table 7).

Were many adults recaptured within the 75-mile radius? Did all of the lake trout move out of the local waters at Port Washington as they approached adulthood or were most of the trout local residents? These questions are of vital importance to the commercial fishermen. Table 7 lists the number of adult ($1\frac{1}{2}$ pounds or more) and young trout recovered at various distances from Port Washington. Only eight adult fish (8.9 per cent) were retaken locally within the 10-mile radius. The greatest number (40 per cent) was recovered within the 11- to 25-mile zone. If we assume that a radius of 50 miles marks the limit of the "local" waters off any port, then it may be seen from Table 7 that fifty-one fish or 56.7 per cent of the recaptured adults were taken in Port Washington waters. If a 25-mile radius is assumed to be the limit of the fishing waters, then forty-four individuals or 48.9 per cent of the adults were caught on Port Washington grounds. As was true for the long-distance travelers, so also the more local adult trout tended to move in a northerly direction (Table 7). As was to be expected, most of the young trout were recaptured in local waters—77 fish or 60.2 per cent within 10 miles and 115 fish or 89.8 per cent within 25 miles of Port Washington (Table 7). If, as is indicated by the data, 50 per cent of the baby trout of any locality that have reached adult size are recaptured in that locality, it would pay the fishermen to take every precaution to protect every baby trout on their fishing grounds, for by doing so they are protecting primarily their own private interests.

To summarize, it was shown that not until about three years after release did the tagged lake trout become fairly well scattered throughout Lake Michigan. Up until this time most of them were recaptured

**TABLE 7. NUMBER AND PERCENTAGE OF TAGGED ADULT ($1\frac{1}{2}$ POUNDS OR MORE) AND YOUNG LAKE TROUT RECAPTURED AT VARIOUS DISTANCES FROM PORT WASHINGTON, WISCONSIN**

| Distance in miles between points of tagging and recapture | Number of adult trout recovered | | | | | | Total adult trout recovered | | Total number of young trout recovered |
|---|---|---|---|---|---|---|---|---|---|
| | Off Port Washington | North of Port Washington | | South of Port Washington | | | | | |
| | | Wis. | Mich. | Wis. | Illinois | Mich. | Number | Per cent of total | |
| 1 to 10 | 8 | | -- | -- | -- | -- | 8 | 8.9 | 77 |
| 11 to 25 | -- | 35 | -- | 1 | -- | -- | 36 | 40.0 | 38 |
| 26 to 50 | -- | 1 | -- | 6 | | -- | 7 | 7.8 | 3 |
| 51 to 75 | -- | 8 | -- | 1 | 2 | -- | 11 | 12.2 | 9 |
| 76 to 100 | -- | 5 | 3 | -- | 3 | 1 | 12 | 13.3 | 1 |
| 101 to 125 | -- | 10 | 1 | -- | -- | 1 | 12 | 13.3 | 0 |
| 126 to 150 | -- | 2 | -- | -- | -- | -- | 2 | 2.2 | 0 |
| 151 to 175 | -- | -- | | -- | -- | -- | 0 | | 0 |
| 176 to 200 | -- | -- | 1 | -- | -- | -- | 1 | 1.1 | 0 |
| 201 to 225 | -- | -- | 1 | -- | -- | -- | 1 | 1.1 | 0 |
| Total | 8 | 61 | 6 | 8 | 5 | 2 | 90 | 99.9 | 128 |
| Per cent of total | 8.9 | 67.8 | 6.7 | 8.9 | 5.6 | 2.2 | 100.1 | -- | -- |

within 25 miles from Port Washington. All trout, but one, recaptured beyond the 75-mile zone were adults. The trout, both young and adult, tended to move in a northerly direction from Port Washington. The young trout remained close to the western shore, even when travelling long distances. With the attainment of adulthood the trout moved in all directions from Port Washington, although nearly 50 per cent of the recaptured adults were taken within 25 miles from this port. Eight trout, all adults, crossed the lake to the Michigan shore. Six lake trout, including one young individual, were recovered in Illinois waters. No tagged lake trout were recaptured in Indiana waters or in Lake Huron. Ninety per cent of the recovered tagged young trout were retaken within 25 miles from Port Washington. The movement of fish across state boundaries emphasizes the need for uniform regulations on the lake.

## Growth of Recaptured Lake and Rainbow Trout, Whitefish, and Sturgeon

Tables 8, 9 and 10 summarize the available data on the growth of the recaptured lake trout, whitefish, rainbow trout, and sturgeon during the periods between tagging and recapture. The data were summarized for intervals of one year to obtain an estimate of the amount of growth in the different years of life. No fish recovered within three months of release were considered in the studies of growth. All lengths are given in inches, all weights in pounds. For many recaptured lake trout and whitefish only length or weight was given. The missing measurement was then supplied by us from a conversion table based on many specimens collected by the U. S. Bureau of Fisheries and the Wisconsin Conservation Department.

Schneberger's study (1935) of the scales of Lake Michigan lake trout and Surber's experiments (1933) on the rearing of this species indicate that the trout of the average sizes shown in Table 8 had completed about 2¼ years of life at the time of tagging (nearly all of the trout were tagged in June and July; they averaged 12.8 inches) or about 2½ growing seasons, assuming that most of the growth took place during the summer. The estimated ages of the recaptured lake trout are given in terms of growing seasons. The fish that had been out from three to six months (recaptured approximately during October-December; computed from July 1) had passed through the third summer's growth, whereas those that had been free from six months to one year and six months (January 1 to January 1) were assumed to have lived through 3½ growing seasons (July 1 was used as the mid-point).

The data indicate that a 3-year-old trout averages 13 inches in length and 0.7 pound (11 ounces) in weight. However, it appears that these figures are too low since the grand average for all of the trout at tagging was 12.8 inches. It is obvious that the fish recaptured from three to six months after tagging were below average size.

**TABLE 8. GROWTH IN LENGTH (INCHES) AND WEIGHT (POUNDS) OF TAGGED LAKE TROUT**

| Time between tagging and recapture | Number of fish | Estimated age (growing seasons) | Size at tagging Length | Size at tagging Wt. | Size at recapture Length | Size at recapture Wt. | Total increase Length | Total increase Wt. | Annual increase Length | Annual increase Wt. |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 to 6 months | 7 | 3 | 11.3 | 0.5 | 13.0 | 0.7 | 1.7 | 0.2 | .. | .. |
| 6 months to 1 year, 6 months | 42 | 3½ | 12.8 | 0.7 | 16.3 | 1.5 | 3.5 | 0.8 | 3.5 | 0.8 |
| 1 year, 6 months to 2 years, 6 months | 24 | 4½ | 12.8 | 0.7 | 19.8 | 2.6 | 7.0 | 1.9 | 3.5 | 1.1 |
| 2 years, 6 months to 3 years, 6 months | 26 | 5½ | 12.5 | 0.7 | 22.2 | 3.9 | 9.7 | 3.2 | 2.7 | 1.3 |
| 3 years, 6 months to 4 years, 6 months | 13 | 6½ | 12.5 | 0.6 | 23.8 | 5.0 | 11.3 | 4.4 | 1.6 | 1.2 |
| 4 years, 6 months to 5 years, 6 months | 4 | 7½ | 11.5 | 0.5 | 22.9 | 4.4 | 11.4 | 3.9 | 0.1 | —0.5 |
| 5 years, 6 months to 6 years, 6 months | 2 | 8½ | 13.2 | 0.7 | 29.1 | 9.1 | 15.9 | 8.4 | 4.5 | 4.5 |
| 6 years, 6 months to 7 years, 6 months | 2 | 9½ | 12.0 | 0.6 | 26.6 | 6.7 | 14.6 | 6.1 | —1.3 | —2.3 |

To determine more accurately the average length of the 3-year-old trout we may add the estimated increase in length (1.7 inches) of the fish during the 3- to 6-month interval to the grand average length (12.8 inches) of the trout at tagging. The 3-year-old trout then averaged 14.5 inches in length and 0.9 pound (14.4 ounces) in weight. At 3½ years of age the trout averaged 16.3 inches in length and 1.5 pounds in weight, the minimum weight limit adopted by most of the Great Lakes states. It is to be noted that during the first three years the trout grew on the average about 0.3 pound per year, then increased 0.6 pound during the next six months, and thereafter, at least for three years, added from 1.1 to 1.3 pounds per annum to their weight. It is apparent that a minimum size limit of 1½ pounds is uneconomical because trout of this weight have just entered their period of rapid growth.

It has been asserted that most of the female lake trout probably do not spawn until they reach a weight of about 3½ pounds. At this size they are approximately 5 years old. The average weight of the spawning lake trout is perhaps about 5 pounds. These fish would be about 6½ years old.

The oldest lake trout recovered was tagged July 29, 1931, at a length of 11½ inches and recaptured off Chicago in the fall of 1938, about 7¼ years after release, at a weight of 5 pounds. This fish was approximately 9½ years of age. Since its mouth was deformed by the tag this individual in all probability did not grow at the normal rate. The second oldest individual had been free six years, ten months, and twenty-seven days. It was tagged at a length of 12½ inches on July 29, 1931. The fish was approximately 9¼ years of age and had attained a weight of 7¼ pounds. A third individual that had been out six years, four months and an unknown number of days was retaken at a weight of 4½ pounds and at an estimated age of 8 years and 8 months.

The largest trout recaptured weighed 10 pounds, 2 ounces dressed (estimated 12.6 pounds in the round and 33¼ inches long). It was tagged at 13½ inches, recovered after five years, nine months, and twenty-three days, and was approximately 8 years and 2 months of age. The next largest individual weighed 10 pounds, 2 ounces in the round and measured 29 inches in length. It was tagged at 14 inches, and had been free only three years, ten months, and twenty-three days. It was, therefore, about 6 years and 2 months old.

The whitefish averaged 11.8 inches at tagging (Table 2), but those that were recaptured after three months of freedom averaged 12.4 inches when tagged. Since a number of older fish were included in the grand average it may be assumed that the average length of the dominant age group was somewhat less than 11.8 inches. Van Oosten's (1939) data on the Lake Huron whitefish indicate that individuals of such length are about 2½ years old. If we assume a comparable growth for the Lake Michigan whitefish then most of those

TABLE 9. GROWTH IN LENGTH (INCHES) AND WEIGHT (POUNDS) OF TAGGED WHITEFISH

| Time between tagging and recapture | Number of fish | Estimated age in years | Size at tagging Length | Size at tagging Wt. | Size at recapture Length | Size at recapture Wt. | Total increase Length | Total increase Wt. | Annual increase Length | Annual increase Wt. |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 to 6 months | 1 | 4 | 16.0 | 1.3 | 17.0 | 1.6 | 1.0 | 0.3 | -- | -- |
| 6 months to 1 year, 6 months | 11 | 3½ | 12.7 | 0.6 | 15.3 | 1.1 | 2.6 | 0.5 | 2.6 | 0.5 |
| 1 year, 6 months to 2 years, 6 months | 4 | 4½ | 11.4 | 0.5 | 17.4 | 1.7 | 6.0 | 1.2 | 3.4 | 0.7 |
| 2 years, 6 months to 3 years, 6 months | 2 | 5½ | 11.8 | 0.5 | 20.1 | 2.6 | 8.3 | 2.1 | 2.3 | 0.9 |
| 3 years, 6 months to 4 years, 6 months | 1 | 6½ | 11.5 | 0.5 | 20.0 | 2.6 | 8.5 | 2.1 | 0.2 | 0.0 |

TABLE 10. GROWTH IN LENGTH (INCHES) OF THREE TAGGED RAINBOW TROUT AND ONE STURGEON

| Species | Date of tagging | Date of recapture | Time between tagging and recapture | Length at tagging | Length at recapture | Increase in length |
|---|---|---|---|---|---|---|
| Rainbow trout | July 18, 1930 | April 20, 1931 | 9 months, 2 days | 21.5 | 23.0 | 1.5 |
| Rainbow trout | June 29, 1929 | April 18, 1930 | 9 months, 20 days | 16.0 | 18.0 | 2.0 |
| Rainbow trout | July 6, 1929 | April 28, 1930 | 9 months, 22 days | 20.0 | 21.5 | 1.5 |
| Sturgeon | January 13, 1930 | June 7, 1933 | 3 years, 4 months, 25 days | 21.0 | 24.0 | 3.0 |

tagged in June and July (nearly all of them) were about 2½ years old and had completed about 2½ growing (summer) seasons. The estimated ages of the recaptured whitefish are given in terms of actual years of life (Table 9).

The data are too few to permit a detailed discussion. They indicate, however, that in 3½ years the whitefish reach a length of about 15.3 inches and a weight of 1.1 pounds. Since the increase during the last year was 0.5 pound the fish must have grown 0.6 pound in 2½ years, or a little more than 0.2 pound per annum. The data suggest that the increment in weight increases (0.5, 0.7, 0.9) each year up to at least the sixth year of life. A 2-pound whitefish, the minimum size limit on most of the Great Lakes waters, is probably about 5 years old in Lake Michigan. As was true for the lake trout, so also the minimum size limits on the whitefish permit the capture of the fish during their period of very rapid growth.

The oldest whitefish recaptured had been free three years, nine months, and twenty-one days and was about 6 years and 2 months of age. During that period it reached a length of 20 inches and a weight of 2 pounds in the round. It was tagged at a length of 11½ inches on July 14, 1931, and recaptured on May 5, 1935, at Cedar Grove, Wisconsin. The second oldest whitefish was at liberty three years, two months, and five days. This individual was probably 5½ years old, during which period it attained a weight of 3 pounds in the round. This fish was the heaviest tagged whitefish retaken. It was 12 inches long when tagged on July 15, 1930, and was recovered on September 20, 1933, at Two Rivers, Wisconsin.

Table 10 gives the growth in length of three tagged rainbow trout and one sturgeon. The rainbow trout increased their length from 1.5 to 2.0 inches during the 9½-month period from the first half of July to the following April when they were caught en route or on the spawning grounds in Michigan. The rainbow trout tagged in 1929, 1930, and 1931 ranged in length from 6 to 30 inches. About 15 per cent of these were less than 12 inches long. It would be of interest to know the origin of these small fish found along the Wisconsin shore.

The recaptured sturgeon grew from 21 inches (2 pounds) to 24 inches (5 pounds) during the interval of nearly three years and five months, from January 13, 1930, to June 7, 1933. The three tagged sturgeon measured 21, 25, and 32 inches, respectively.

## Summary

1. Systematic tagging of 2,902 Lake Michigan fish was begun by Smith Brothers at Port Washington, Wisconsin, on June 20, 1929, and continued until August 4, 1931. Virtually all of the tagging was done during the summer months.

2. Lake trout comprised 48.8 per cent of the fish tagged and lake trout, lake herring, and whitefish (mostly young fish) composed 85.0 per cent.

3. A total of 388 fish or 13.4 per cent of the tagged fish was recaptured. The percentages of returns varied from 5.4 for the herring to 75.0 for the sturgeon. About 22 per cent of the tagged whitefish and 15 per cent of the tagged lake trout were retaken.

4. The percentages of returns for the lake trout, whitefish, and sturgeon indicate a tremendous fishing intensity in Lake Michigan. Eighty per cent of the five tagged sturgeon were recovered. It was estimated that more than 31 per cent of the baby lake trout (12.8 inches) and more than 44 per cent of the young whitefish (11.8 inches) later entered the commercial nets. About 28 per cent of these recovered lake trout were legal in size and about 14 per cent of these recaptured whitefish were of legal length.

5. About 51 per cent of the recovered fish were taken 10 miles or less from Port Washington, Wisconsin, and 81 per cent were taken within a radius of 25 miles from this port. The data indicate that, in contrast to the lake trout, rainbow trout, and sturgeon, the lake herring, whitefish, chubs, pilots and perhaps perch were not extensive travelers. However, there may have been some correlation between distance travelled and the period of freedom. Nearly all of the chubs and pilots were recovered within twenty days after release and within 10 miles from Port Washington. Nearly all of the perch and herring were retaken within sixty days after tagging and within 25 miles from this port. Seventy-four per cent of the whitefish were recaptured within sixty days, and only four of the 101 recovered individuals were taken outside the 25-mile zone. There appeared to be no correlation between distances travelled by the whitefish and time out. The whitefish is undoubtedly a non-migratory species.

6. Maximum distances travelled, direction of migration, and maximum periods of freedom after tagging are given for the different species. The herring and whitefish tended to move in a northerly direction from Port Washington, at least as far as Two Rivers (about 55 miles), the perch in a southerly direction, at least as far as Kenosha (about 57 miles), and the rainbow trout to the east to the Michigan shore. Too few data were available for the chubs, pilots, lawyer, and carp, although the one eight-month record of the pilot indicated that this species is non-migratory. The sturgeon apparently roam throughout the lake. The rainbow trout are the fast travelers in the lake.

7. Fifty-three per cent of the recovered lake trout were recaptured within one year of release, and 73 per cent were retaken within 25 miles from Port Washington. It required three years for the trout to become fairly well scattered throughout the lake. All trout, but one, recaptured beyond the 75-mile zone were adults. The trout, both young and adult, tended to move in a northerly direction from Port Washington. The young trout remained close to the western shore, even when travelling long distances. With the attainment of adulthood the trout moved in all directions from Port Washington, although

nearly 50 per cent of the recaptured adults were taken within 25 miles from this port. Eight trout, all adults, crossed the lake to the Michigan shore. Six lake trout, including one young individual, were recovered in Illinois waters. No tagged lake trout were recaptured in Indiana waters or in Lake Huron. Ninety per cent of the recovered tagged young trout were retaken within 25 miles from Port Washington. The movement of fish across state boundaries emphasizes the need for uniform regulations on the lake.

8. Data are given on the growth and estimated age of the tagged lake trout, rainbow trout, whitefish, and sturgeon. It is indicated that the minimum size limits of the lake trout and whitefish of the Great Lakes are economically unsound—they are too low—because at these limits the fishermen are permitted to take individuals that have just entered their period of most rapid growth in weight. The oldest tagged lake trout recovered had been free about 7¼ years and was approximately 9½ years old. It weighed 5 pounds. The largest lake trout recovered weighed about 12.6 pounds and was approximately 8 years and 2 months of age. The oldest tagged whitefish recaptured had been at liberty three years, nine months, and twenty-one days, and was about 6 years and 2 months old. It had reached a length of 20 inches and a weight of 2 pounds. The heaviest whitefish retaken weighed 3 pounds. It was probably 5½ years old. The three rainbow trout (16.0 to 21.5 inches) increased their length from 1.5 to 2.0 inches during a 9½-month period from the first half of July to the following April. The one recaptured sturgeon grew from 21 inches (2 pounds) to 24 inches (5 pounds) during an interval of nearly three years and five months.

## Literature Cited

Cole, Leon J.
1905. The German carp in the United States. Report, Bureau of Fisheries, 1904, pp. 523-641.

Markus, Henry C.
1933. The effects of tags upon fresh water fishes. Trans. Am. Fish. Soc., 1933, Vol. 63, pp. 319-325.

Milner, James W.
1874. Report on the fisheries of the Great Lakes; the result of inquiries prosecuted in 1871 and 1872. Report, U. S. Fish Commission, 1872 and 1873, pp. 1-78.

Ontario Game and Fisheries Department
1930. Twenty-third Annual Report, 1929, p. 19. Toronto.

Schneberger, Edward
1935. Notes regarding lake trout of Lake Michigan and Green Bay. Wisconsin Conservation Department (Typewritten Report).
1936. Tagged trout reveal new facts and figures. The Fisherman, Vol. 5, No. 7, p. 1. Grand Haven, Michigan.

Shetter, David S.
1936. The jaw-tag method of marking fish. Papers Mich. Acad. Sci., Arts and Letters, Vol. XXI, 1935, pp. 651-653.

1938a. Rainbows are the travelers of trout species. Michigan Conservation, Vol. 7, No. 8, pp. 6-7; 11. Lansing, Mich.

1938b. Tagging of lake trout in Lake Michigan, November 7, 1938. Report No. 502, Michigan Institute for Fisheries Research (Typewritten Report).

Smith, Lester
1933. Tagging Lake Michigan fish. The Fisherman, Vol. 2, No. 5, pp. 3-4, 11-12; No. 6, p. 11.

Snyder, J. P.
1932. Tagged smallmouth black bass in Lake Ontario, N. Y. Trans. Am. Fish. Soc., 1932, Vol. 62, pp. 380-381.

Surber, Thaddeus
1933. Rearing lake trout to maturity. The Minnesota Conservationist, No. 5, pp. 9, 22. St. Paul, Minn.

The Fisherman
1933. Mystery of sturgeon "41" solved. Vol. 2, No. 7, p. 12. Grand Haven, Mich.

Van Oosten, John
1933. Preliminary report on investigation of chubnet meshes in Lake Michigan. The Fisherman, Vol. 2, No. 4, pp. 3-4, 8.

1939. The age, growth, sexual maturity, and sex ratio of the common whitefish, *Coregonus clupeaformis* (Mitchill), of Lake Huron. Papers, Mich. Acad. Sci., Arts and Letters, Vol. XXIV, Pt. II, 1938, pp. 195-221.

# AN EVALUATION OF TROUT CULTURE[1]

FREDERIC F. FISH
*U. S. Bureau of Fisheries, Seattle, Washington*

ABSTRACT

In an evaluation of the efficiency of trout culture, the author presents a detailed analysis of complete loss records from 288 individual lots of trout at twenty-two hatcheries in the western United States. Summarized data are given to show the percentage loss of eggs, fry, and fingerlings by progressive one-half inch size groups. The accumulative percentage loss is also included to indicate the losses, under average hatchery conditions, between the egg stage and each successive size-group. These data cover the individual species of trout commonly reared in hatcheries; summarized data are given also for all species combined. A brief discussion of hatchery losses, natural losses, and the cost of artificial propagation is included.

Trout culture, as an institution, is approaching its one-hundredth birthday, and it is indeed surprising that in this long period few serious attempts have been made to evaluate the efficiency of the hatchery system. This information would be of considerable value to the hatchery men as a basis for comparing the efficiency of their own establishments in relation to the general average. Likewise, fisheries managers would find these data of material aid in estimating the approximate number of fish of any given size that may be expected to become available for stocking from a known number of eggs taken into the hatchery.

Theoretically, at least, artificial propagation offers a distinct advantage over natural propagation as a method for assuring a dependable and continuous supply of young trout to replace the larger ones taken by the anglers. The hatcheries furnish a protected environment to young fish during the more vulnerable stages in their life history—albeit only at a considerable price. However, the necessary crowding of fish in the ponds and troughs of the hatcheries facilitates greatly the transmission of pathogenic organisms. Thus, the problem of disease—a factor that is seldom of material consequence in the wild—is introduced in the hatchery. Losses from disease may nullify all other advantages offered by artificial propagation.

Few accurate data have been assembled upon the probable survival of young trout during their hatchery life. In the absence of definite information, it has been virtually impossible to determine the actual value of the extensive system of trout hatcheries. Likewise, little is known, for purposes of comparison, of the more vulnerable periods in the life of the wild trout although the more accurate estimates now available indicate that the greatest losses occur between the time of

[1]Published by permission of the Commissioner of Fisheries.

emergence from the gravel and the No. 3 fingerling stage. Therefore, the most satisfactory results from trout culture should be realized from rearing a maximum number of trout to a minimum length of 3 inches at the lowest possible cost. By rearing trout to this size in the protected environment of the hatchery, the greatest losses in Nature can be obviated. Just how successfully the trout hatcheries as a whole may be approaching this goal is not known, primarily because of the scarcity of accurate and adequate data.

During the past four years, Bureau hatcheries in the Western District have reported each week the losses, insofar as possible by actual count, on individual shipments or takes of eggs from the time they entered the hatchery until all of the resulting fish were subsequently liberated. In addition, pertinent data as to average length of the fish, disease treatments and their effect, and, recently, the composition, amount, and cost of the food have likewise been required. As particular emphasis has been placed upon the accuracy of the records, it is believed that the resulting data are as accurate as can be obtained under routine hatchery conditions and that they describe closely the actual state of affairs. During the four-year period, complete records have been obtained from 288 individual lots of trout at twenty-two separate hatcheries scattered from western Nebraska to the Pacific coast. This sampling should be sufficiently large to minimize the effect of individual variations. As these twenty-two hatcheries are no worse, and probably no better, than hatcheries elsewhere, a reliable estimate of the losses attending trout culture has been obtained.

In the compilation of these data, the weekly loss records on each lot of trout were carefully checked for possible arithmetic errors and all lots showing incomplete or confusing figures were discarded. Likewise, losses resulting from purely accidental causes and the so-called "unaccountable losses" which usually become apparent at the final liberation, were not included. However, no attempt was made to eliminate the effects of losses from disease which appears primarily responsible for the increased losses at the No. 2 and No. 3 fingerling stages. The records were then summarized by species and the total numbers of fish on hand and the numbers lost at progressively greater sizes obtained. The percentage loss occurring at each size was then derived from these figures. In addition, an accumulative percentage loss was also determined for each species by assuming a hypothetical number of 100 eggs and progressively subtracting the percentage loss occurring at each size. Thus, the accumulative percentage losses indicate the losses that may be expected on each 100 eggs under average hatchery conditions up to, and including, any particular size.

The data on hatchery losses, summarized by species and for all species combined, appear in Table 1.

From the standpoint of the number of legal-sized trout produced, these data on hatchery production, coupled with those of Davis (1938)

TABLE 1. SUMMARIZED DATA ON TROUT PRODUCTION

| Item | Eggs[1] | Fry | No. 1 | No. 1½ | No. 2 | No. 2½ | No. 3 | No. 3½ | No. 4 |
|---|---|---|---|---|---|---|---|---|---|
| | | | Size-groups in inches | | | | | | |
| **Loch Leven trout** | | | | | | | | | |
| Number of hatcheries reporting | 12 | 12 | 12 | 9 | 9 | 5 | 3 | .. | 1 |
| Number of individual lots reported | 21 | 21 | 21 | 15 | 12 | 6 | 3 | .. | 1 |
| Total number of fish handled[2] | 12,427 | 10,014 | 5,832 | 3,113 | 1,802 | 505 | 129 | .. | 69 |
| Total number of fish lost[2] | 808 | 241 | 540 | 122 | 56 | 41 | 18 | .. | 2 |
| Percentage loss | 6.5 | 2.41 | 9.26 | 3.91 | 3.10 | 8.10 | 13.99 | .. | 2.19 |
| Accumulative percentage loss | 6.5 | 8.75 | 17.20 | 20.44 | 22.91 | 29.15 | [3].. | [3].. | [3].. |
| **Brook trout** | | | | | | | | | |
| Number of hatcheries reporting | 20 | 20 | 20 | 16 | 16 | 13 | 13 | 2 | 7 |
| Number of individual lots reported | 74 | 75 | 75 | 62 | 51 | 40 | 31 | 3 | 11 |
| Total number of fish handled[2] | 52,546 | 26,811 | 24,985 | 16,165 | 9,309 | 7,103 | 3,764 | 181 | 517 |
| Total number of fish lost[2] | 4,142 | 1,614 | 1,901 | 1,410 | 347 | 293 | 501 | 16 | 31 |
| Percentage loss | 7.88 | 6.02 | 7.61 | 8.72 | 3.73 | 4.13 | 13.31 | 8.94 | 6.03 |
| Accumulative percentage loss | 7.88 | 13.43 | 20.02 | 27.00 | 29.73 | 32.62 | 41.60 | 46.82 | 50.03 |
| **Blackspotted trout** | | | | | | | | | |
| Number of hatcheries reporting | 22 | 23 | 22 | 15 | 9 | 4 | 5 | 2 | 2 |
| Number of individual lots reported | 77 | 78 | 64 | 36 | 15 | 6 | 7 | 2 | 3 |
| Total number of fish handled[2] | 31,255 | 26,053 | 16,919 | 4,860 | 1,856 | 229 | 526 | 26 | 288 |
| Total number of fish lost[2] | 1,960 | 1,712 | 1,605 | 361 | 283 | 55 | 14 | .. | 52 |
| Percentage loss | 6.27 | 6.57 | 9.48 | 7.42 | 15.23 | 23.98 | 2.65 | 0.47 | 18.13 |
| Accumulative percentage loss | 6.27 | 12.43 | 20.73 | 26.61 | 37.79 | [3].. | [3].. | [3].. | [3].. |
| **Rainbow trout** | | | | | | | | | |
| Number of hatcheries reporting | 20 | 21 | 18 | 14 | 14 | 9 | 10 | 2 | 7 |
| Number of individual lots reported | 104 | 102 | 93 | 72 | 63 | 35 | 31 | 4 | 10 |
| Total number of fish handled[2] | 35,526 | 20,533 | 15,932 | 8,868 | 7,408 | 3,299 | 3,069 | 172 | 1,154 |
| Total number of fish lost[2] | 6,252 | 1,789 | 1,425 | 728 | 436 | 241 | 103 | 3 | 34 |
| Percentage loss | 17.6 | 8.71 | 8.95 | 8.21 | 5.89 | 7.30 | 3.35 | 2.00 | 2.97 |
| Accumulative percentage loss | 17.6 | 24.78 | 31.52 | 37.15 | 40.86 | 45.18 | 47.02 | 49.08 | 49.63 |
| **Steelhead trout** | | | | | | | | | |
| Number of hatcheries reporting | 6 | 6 | 6 | 5 | 5 | 4 | 4 | .. | .. |
| Number of individual lots reported | 12 | 12 | 13 | 8 | 10 | 6 | 4 | .. | .. |
| Total number of fish handled[2] | 6,617 | 3,990 | 4,157 | 1,961 | 1,090 | 472 | 263 | .. | .. |
| Total number of fish lost[2] | 1,204 | 78 | 155 | 43 | 125 | 27 | 9 | .. | .. |
| Percentage loss | 18.2 | 1.94 | 3.73 | 2.20 | 11.51 | 5.71 | 3.28 | .. | .. |
| Accumulative percentage loss | 18.2 | 19.79 | 22.78 | 24.48 | 33.17 | 36.99 | 39.06 | .. | .. |
| **All species combined** | | | | | | | | | |
| Number of hatcheries reporting | 22 | 23 | 22 | 16 | 16 | 13 | 13 | 2 | 7 |
| Number of individual lots reported | 288 | 268 | 267 | 194 | 152 | 93 | 76 | 9 | 25 |
| Total number of fish handled[2] | 138,371 | 87,401 | 67,825 | 34,967 | 21,464 | 11,609 | 7,751 | 379 | 2,027 |
| Total number of fish lost[2] | 14,365 | 5,432 | 5,626 | 2,663 | 1,247 | 657 | 644 | 20 | 119 |
| Percentage loss | 10.38 | 6.22 | 8.30 | 7.62 | 5.81 | 5.66 | 8.31 | 5.17 | 5.88 |
| Accumulative percentage loss | 10.38 | 15.95 | 22.92 | 28.79 | 32.93 | 36.73 | 41.99 | 44.99 | 48.22 |

[1]Data on eggs are not complete as in many instances eggs were shipped to, or received from, hatcheries of other agencies wherein no records were obtainable. It is estimated that the unavailable data would not increase the estimate of the egg losses over 1 per cent.

[2]Data on total number of fish handled and total number of fish lost expressed in thousands.

[3]Data lacking or not reliable.

on natural losses, further emphasize the superior results to be obtained from rearing trout to the larger sizes in the hatchery.

It is usually assumed that 100 trout eggs developing under natural conditions will produce approximately two legal-sized fish. If the same 100 eggs were taken into the hatchery, seventy-seven No. 1 fingerlings should result and, if the fish are liberated at this size, 5 per cent could be expected to survive yielding a total of four legal-sized fish. By the same process of reckoning, the 100 hypothetical trout eggs in the hatchery potentially represent, under average conditions, sixty-seven No. 2's, fifty-eight No. 3's, and fifty-two No. 4's, from which could be anticipated thirteen, twenty-nine and thirty-six legal-sized fish, respectively. Thus, 100 trout eggs potentially represent from two to thirty-six legal trout, depending upon the length of time they are retained in the hatchery.

Although the artificial propagation of trout undoubtedly yields superior results numerically, it does so only at a price. The actual cost of trout production is very difficult to determine. Food costs are obvious and easily obtained but they represent only a fraction of the entire cost. The amount spent for labor, construction, maintenance, distribution, and administration in the aggregate undoubtedly comprises the greater part of the cost of trout culture. These items are not only very difficult to determine but equally so to apportion fairly among the lots of fish. There have been only a few isolated attempts to obtain total production costs for trout culture. Perhaps the most inclusive was the study by Mottley (1935) who estimated the cost of producing No. 3 brown trout to be $24.00 per thousand. This figure included only wages, the cost of fry ($1.75 per thousand), and a proportion (10 per cent) of the costs of pond construction. It is probable that the items not included would increase this figure to about $30.00 per thousand.

Assuming $30.00 per thousand to be a fair average price for producing 3-inch fish, the cost of hatchery operations is not prohibitive in view of the results obtained. If we apply this cost of production to the probable returns from liberating No. 3 fingerlings previously given, we can make an estimate of the cost of producing legal-sized trout from plantings of 3-inch fish. One hundred eggs in the hatchery, liberated as No. 3's, represent a potential value of twenty-nine legal-sized fish—an increase of twenty-seven fish over natural production. It cost but $1.74 to produce these twenty-seven fish in the hatchery—or approximately six cents per legal fish. This price seems most reasonable in comparison with the sum spent by the angler to catch a fish.

From this type of data, one can formulate his own conclusions as to the present efficiency of trout culture. The loss of approximately one-half the fish in hatcheries between the egg stage and No. 4 fingerlings does not prevent a reasonable return on the money invested in spite of the fact that this loss is much higher than is desirable. A

more general application of the cardinal principles of scientific fish culture now known and the ready adoption of those which inevitably will be revealed through future research would result in a marked increase in the efficiency of artificial propagation.

## Literature Cited


Davis, Herbert S.
1938. Instructions for conducting stream and lake surveys. U. S. Department of Commerce, Bureau of Fisheries, Fishery Circular No. 26, 55 pp., Washington, D. C.

Mottley, C. McC.
1935. Objectives in the pond culture of salmonid game fish. Trans. Am. Fish. Soc., Vol. 65, pp. 172-178.


---

## Discussion

The Chairman: In these days when fish culture is coming more and more to connote artificial propagation and fish management and natural propagation, it is a relief to hear a paper of this sort, which would seem to indicate that artificial propagation still has its merits. This paper is now open for discussion.

Mr. Leo Shapovalov: Dr. Fish said that in his calculations he had omitted the so-called unaccounted loss and also the loss due to accidental causes. Why were these omitted?

Dr. Fish: The only trouble with the unaccounted loss arises from the necessity of determining how you are going to apportion it along the line. Did that happen as No. 1 or No. 4?

Mr. Shapovalov: If you are calculating the cost, as long as it does happen, it has to be taken into consideration.

Dr. Fish: That is quite true. No doubt I should have included accidental causes, but then it is pointed out that these losses are not normal, that they happen only once in a while. I have to draw the line somewhere. As a matter of fact the totals would not be greatly affected. The unaccounted loss under this system is very slight—I would guess about 2 per cent of the total number of eggs taken.

# POLLUTION CONTROL IN CALIFORNIA

Paul A. Shaw

*In Charge Pollution Control, Division of Fish and Game, San Francisco, California*

Abstract

**Pollution problems in California are compared with those of the United States as a whole. The expansion of control activities and the cooperative, technical, and enforcement features of our present program are discussed. The success of a plan correlating technical and enforcement work is emphasized.**

---

California is justly proud of her diversified climate, topography, and recreational and natural resources, but these same attractions have promoted the establishment of industries creating an equally wide variety of pollution problems, each of which requires detailed study and individual methods of correction. Although the opinion is often expressed that major pollution problems are confined to the Eastern States, it may be ascertained from Federal statistics recently published (National Resources Committee, 1939) that only four other states in the Union outweigh California in the value of manufactured products whose wastes contribute to pollution. The same bulletin indicates that California requires 10 per cent of the national investment needed to abate municipal sewage pollution. The needs of California are equal to those of all other states lying in the western two-thirds of our nation. The California State Division of Fish and Game has been a leader in the expanding nation-wide activities to attain cleaner waterways, and it is the purpose of this paper to describe certain general features of the program which we feel have contributed to effective action.

Five years ago only one man was definitely assigned to pollution studies by the Division. Since that date, the personnel has been increased steadily until at present nine men are assigned to full-time duty on the Pollution Detail. In the majority of states, pollution abatement is chiefly a function of the Health Department, but in California industrial wastes come primarily under the control of the Division of Fish and Game and sewage disposal under the former agency. The functions overlap to the extent that any industrial waste affecting public health may be regulated by the Health Department, whereas any sewage effluent shown to be deleterious to fish and aquatic life comes within the provisions of the Fish and Game Code.

Under the present program, pollution control is considered to be fundamentally a problem of law enforcement. However, the determination of scientific facts and the application of proper engineering principles in devising remedial measures necessitate equal emphasis on the investigational and technical phases of the work. The staff is

therefore composed both of technically trained men and enforcement officers.

Although the writer is directly in charge of the Detail, enforcement work and court cases are supervised to a large extent by Mr. C. L. Towers, a Senior Warden. Naturally, our opinions have been at times somewhat divergent, but the discussions growing out of our work together have given each of us an understanding of the other's viewpoints. There has resulted a correlation of technical and enforcement effort largely responsible for the success of the program.

The history of agencies that have attempted to abate pollution through scientific study and cooperative efforts is not particularly encouraging, nor is the story any brighter with organizations that utilize only enforcement measures. The recent debates on proposed Federal legislation have centered principally on this same question of research versus enforcement. Unfortunately, the average technically trained man or sanitary engineer is not suited for enforcement work, and the enforcement officer rarely has the training or disposition for scientific studies. In view of these facts it is felt that sponsors of Federal legislation on pollution should give serious consideration to provision for a staff of scientific investigators from the U. S. Bureau of Fisheries and Public Health Service to work in cooperation with officers from the War Department, a recognized enforcement agency.

Active cooperation with related agencies is an essential feature of our work. The study of winery wastes in the Mokelumne River (Shaw, 1937), was carried out in cooperation with health officials. Affiliation with groups enforcing similar laws has also been of special value. California can be particularly proud of the program now carried on cooperatively by the Pollution Detail and Federal agencies such as the U. S. War Department, U. S. Customs, and U. S. Coast Guard. The accomplishments that resulted from this alliance have been recognized by a number of states which desired to initiate a similar program. The discharge of oil and refuse are Federal as well as state offenses, and evidence secured by either Federal or state officers is freely exchanged.

Detailed reports are submitted following the investigation of complaints or conditions observed on regular patrol. When necessary, further field or laboratory studies are conducted to ascertain the facts. If the data indicate that a violation exists, notices of inspection are issued which cover the condition that must be corrected. While the desire is to secure a remedy through cooperative effort, the necessity for compliance with the law is pointed out in a fair but firm manner.

Immediate prosecutions are limited to violations in which prohibited substances are discharged through negligence or a wilful disregard of the law. No case is brought to court without adequate evidence, including a full written report, pictures, samples, records of analyses, and reliable witnesses. Adherence to this policy has produced an impressive record of successful prosecutions. The increase in the effec-

tiveness of enforcement effort is evident from the records of the past four years which show only fourteen cases with total fines of $550.00 for the year 1935-1936, compared to more than sixty cases with fines totaling in excess of $12,000.00 for the past twelve months. Thus, in this relatively short interval the number of cases has increased more than 400 per cent and the average fine imposed has increased 500 per cent.

In the treatment of problems common to an industry, a group representative is often approached with the suggestion that the industry initiate research work that will lead to the development of approved methods of waste treatment and disposal. In the event of active cooperation, it is customary to grant time for the development and installation of proper equipment rather than to force temporary measures that might prove unsatisfactory and costly, for, in the final analysis, the goal is to correct conditions rather than to show an impressive total in court fines. The burden of responsibility for developing adequate means of disposal rests with the industry, but the staff of the Pollution Detail aids in research programs and is often in a position to suggest the proper procedure or to indicate the proper line of attack. Cooperative programs of this type have been undertaken with many industrial groups among which are included the major oil companies, the commercial fishing interests, the Canners' League, the Wine Institute, and the Gold Producers of California.

Emphasis has been placed on the development of simple and practical procedures for the disposal of wastes rather than on the establishment of elaborate treatment methods that might prove burdensome. Not infrequently the equipment installed to eliminate pollution has resulted in the recovery of by-products which have produced added profit for the concerns. As the result of cooperative and enforcement activities, several millions of dollars have been expended by California industries in recent years for the control of pollution. These installations have resulted in marked improvement in the condition of public waters.

An illustrated bulletin (Shaw and Towers, 1937) discusses many conditions met in the oil, mining, and food industries and describes certain preventive and corrective measures developed. Another article has also been published (Shaw, 1938) that outlines a chemical process developed by the Pollution Detail for the clarification of mine tailings.

In this brief summary it is not intended to discuss detailed technical data, but a few words with reference to equipment and laboratory facilities would seem to be appropriate. Adequate equipment for technical, enforcement, and educational work is obviously a necessity. A laboratory is maintained at the Hooper Foundation for Medical Research where the chemical, bacteriological, and pathological work is conducted. In addition to routine analyses of water and industrial effluents and the examination of fish and mammals, studies are carried

out on methods of analysis, and on the toxicity of chemicals and wastes.

Compact kits are provided for stream surveys and tests in the field, and all patrol officers on the Detail are provided with cameras, sample bottles, and field notebooks. A large mirror has been found very useful for the reflection of sunlight into sewers at manholes when tracing sources of oil pollution. Pictures taken with this lighting have been used as court evidence. Another recent acquisition is a coring device for sampling strata deposited in stream beds or harbor areas.

About a year ago two moving-picture cameras and accessories were purchased for the purpose of obtaining evidence and also for educational work. A special box and screen arrangement has been devised for the exhibition of pictures to a small group without the necessity of darkening the room. While suitable evidence has been taken for a number of court cases, every defendant so far has plead guilty, knowing that moving-picture evidence was on hand.

In the past, transportation for most of the patrol work has been by automobile but more recently Coast Guard vessels have also been utilized. Now a motor launch has been assigned specifically to our work. This boat is headquartered at Stockton, where it is proving valuable for inland-water surveys.

During the past year, aeroplanes operated by the Army, Navy, and Coast Guard have been utilized on several occasions. Aerial photographs are remarkably valuable for outlining the limits of polluted areas, and for showing the position of outlets or sources difficult to locate from the ground.

As is true in many other states, difficulties have occasionally been experienced with industries that have sufficient political influence to delay or prevent the enforcement of remedial measures. In general, however, the technical, cooperative, and enforcement features of the program as here outlined have served to keep industries actively working toward a satisfactory solution of their pollution problems. However, even after remedies have been effected the potential sources of pollution, particularly in the oil, shipping, and mining industries, are such that a continued patrol is essential to prevent the recurrence of careless practices.

## Literature Cited

National Resources Committee
1939. Water pollution in the United States. House Document No. 155, pp. 1-165.

Shaw, Paul A.
1937. Pollution of the Mokelumne River by winery wastes. Sewage Works Journal, 1937, Vol. 9, pp. 599-606.
1938. Chemical clarification of mine tailings. Mining and Industrial News, December 15, 1938, p. 12.

Shaw, Paul A. and C. L. Towers
1937. Water pollution problems in California. California Fish and Game, 1937, Vol. 23, pp. 262-285.

# EXPERIMENTS UPON THE CONTROL OF TRICHODINIASIS OF SALMONID FISHES BY THE PROLONGED RECIRCULATION OF FORMALIN SOLUTIONS[1]

FREDERIC F. FISH

*U. S. Bureau of Fisheries, Seattle, Washington*

AND

ROGER E. BURROWS

*U. S. Bureau of Fisheries, Quilcene, Washington*

ABSTRACT

**In a search for more effective disinfectants to combat parasitic diseases of hatchery fish, the authors report results from a series of experiments designed to determine the toxicity of varying exposures to concentrations of formalin, sodium p-phenolsulphonate, ammonium sulphate, and sodium benzoate. Non-toxic concentrations of these disinfectants were tested, in addition to the usual hatchery methods of salt treatment and hand dipping in copper sulphate and acetic acid solutions, on No. 1 brook trout fingerlings which had been experimentally infected with the protozoan parasite *Trichodina* sp. (previously known as *Cyclochaeta* sp.).**

**Of the disinfectants tested, only formalin completely removed all parasites. Salt treatment in a 5 per cent solution, by weight, as well as hand dipping in 1:500 acetic acid, failed to eradicate all parasites present, although a marked reduction in their numbers did occur. The hand dipping in a 1:2,000 copper sulphate solution was found to be without practical value for the removal of parasites.**

**The authors recommend a prolonged treatment for sixty minutes by recirculating a 1:4,000 solution of formalin, or, where circumstances permit, a 120- to 150-minute exposure to a 1:6,000 concentration of formalin, as the most effective, most economical, and least toxic treatments for combating infections of *Trichodina* sp., and presumably those of other external parasites as well, among hatchery fish.**

## INTRODUCTION

The gradual evolution of fish culture during the past two decades progressively has emphasized the acute necessity for more effective measures to control the ravages of disease. So long as fish culture remained a relatively short-period trough procedure, hand dipping and salt treatments provided easy and reasonably effective methods for controlling the diseases which appeared at the hatcheries. However, as the practice of rearing fish to the larger fingerling sizes was more widely adopted, it became more apparent that hand dipping and salting were hopelessly outmoded methods, utterly inadequate to cope with the disease problems presented by the maintenance of fish in pools and ponds.

Prolonged treatment, developed by Hess (1930) as a method for

[1]Published by permission of the Commissioner of Fisheries.

controlling parasites of pond fishes and later adapted to trout-cultural equipment by Kingsbury and Embody (1932) and by Fish (1933) offered a promising technique for effectively obviating the disadvantages of hand dipping. The earlier methods of both Kingsbury and Embody, and Fish, which involved the direct application of the disinfectant to the inflowing water, can be satisfactorily applied to troughs and small tanks and represent a distinct improvement over hand dipping. However, these early methods for administering prolonged treatments are believed, at least by Fish, for reasons previously published (1939), to be entirely too inaccurate for application to the larger volumes of water contained in pools and ponds. For those types of equipment, Fish recommends the recirculation of a carefully compounded disinfectant-concentration in a closed system.

Although considerable attention has been devoted to the perfection of a suitable technique for treating fish diseases by prolonged treatments, comparatively little has been done towards evaluating the relative efficacy of the many disinfectant-concentrations available for this purpose. Experience with prolonged treatments gained during the past nine years has demonstrated the unsuitability of the commoner hatchery disinfectants because the margin between effective and lethal concentrations is entirely too narrow. One of the projects recently undertaken by the Bureau's Pathology Laboratory at Seattle, Washington, has been a search for more satisfactory hatchery disinfectants for use in prolonged treatments.

## Experiments and Results

In brief, the technique employed in determining the toxicity and the efficacy of any disinfectant consisted in first establishing the maximum concentration that proved non-toxic to lots of 100 fingerling salmon during three successive exposures of equal duration at three-day intervals. The non-toxic concentrations thus established were then tested on individual lots of 1,000 fingerlings which had been experimentally infected with the external protozoan *Trichodina* sp. (previously known as *Cyclochaeta* sp.). A quantitative analysis of the parasites present on five formalin-preserved fish, by means of centrifugalization and direct microscopic count, was made immediately before the treatment was administered and a second count made twenty-four hours later. The direct parasite count has been demonstrated to be the most accurate method available for evaluating the intensity of infections with *Trichodina* sp.

Some selection of the disinfectants to be studied became imperative in view of the larger number which are potentially suitable. It appeared advisable to confine the study primarily to those reagents which, if found effective, would be economically feasible to use in the quantities demanded by hatchery operations.

The non-toxic disinfectant-concentrations tested to date at 47° F. were: sodium benzoate, 1:1,000, two-hour exposures; sodium p-phenol-

sulphonate, 1:1,000, two-hour exposures; ammonium sulphate, 1:5,000, two-hour exposures; and formalin, 1:2,000, one-hour exposures. Of these, only formalin, 1:2,000, was found to be of any practical value in eradicating *Trichodina* sp. from infected fish. In a single one-hour exposure, this concentration of formalin produced a reduction from 1,656 to 0 in the number of parasites present on five experimentally infected fish.

In view of the promising results obtained by the recirculation of formalin, it was decided to investigate this reagent further. In a second series of toxicity determinations, a 1:1,000 concentration of formalin was found non-toxic in thirty-minute exposures at 45° F., although it became definitely toxic in sixty-minute exposures. A 1:2,000 concentration was not toxic in 120-minute exposures at 46.5° F., but was toxic in 240-minute exposures at the same temperature. A 1:3,000 concentration was toxic in 240-minute exposures at 49.5° F. A 1:4,000 concentration for 120-minute exposures at 41.5° F. proved non-toxic as did a 1:6,000 concentration for 180-minute exposures at 47.5° F.

Another series of experimental infections with *Trichodina* was then developed to determine the relative efficacy of the various non-toxic concentrations of formalin in comparison with the customary hatchery-control measures of hand dipping in copper sulphate, 1:2,000; acetic acid, 1:500; and salt treatment in a 5 per cent brine solution. The results obtained in this determination of relative effectiveness are given in Table 1.

**TABLE 1. THE RELATIVE EFFICACY OF VARIOUS TREATMENTS IN REMOVING *TRICHODINA* SP. FROM EXPERIMENTALLY INFECTED NO. 1 BROOK TROUT**

**(Temperature during all treatments—47.5° F.)**

| Disinfectant and concentration[1] | Period of exposure (in minutes) | Number of parasites on five fish: Before treatment | Number of parasites on five fish: Twenty-four hours after treatment |
|---|---|---|---|
| Untreated control | ---- | 3,688 | 3,410 |
| Copper sulphate 1:2,000 | [2]2 | 5,386 | 2,001 |
| Acetic acid 1:500 | [2]2 | 7,334 | 5 |
| Salt 5 per cent | [3]10 | 3,680 | 34 |
| Formalin 1:2,000 | 30 | 4,336 | 19 |
| Formalin 1:2,000 | 60 | 4,214 | 0 |
| Formalin 1:3,000 | 60 | 5,992 | 0 |
| Formalin 1:4,000 | 60 | 3,633 | 0 |
| Formalin 1:4,000 | 120 | 6,285 | 0 |
| Formalin 1:6,000 | 60 | 3,655 | 19 |
| Formalin 1:6,000 | 120 | 1,590 | 0 |
| Formalin 1:6,000 | 180 | 1,975 | 0 |
| Formalin 1:10,000 | 120 | 4,470 | 30 |

[1]All formalin treatments administered by recirculation.
[2]Hand dipping.
[3]Salted in trough.

## Control Measures for Trichodiniasis

Little need be said concerning acetic acid hand dippings other than that they are superior to the practically ineffectual 1:2,000 copper

sulphate hand dipping for the control of Trichodiniasis. However, hand dipping as a general method for treating fish is not only laborious but it involves the highly objectionable necessity for handling large numbers of fish in an extremely unfavorable environment. In view of the results obtained from prolonged treatments, the use of any hand dip is to be avoided in controlling *Trichodina* infections.

Salt treatments, either directly in the troughs or as a hand dipping, has been the time-honored method of treating external protozoan infections of fish. If properly administered, salt treatments will remove a large percentage of the external protozoans present on fish although it does leave a sufficient number of parasites uninjured to initiate reinfection. This fact has been demonstrated several times in various unpublished experiments conducted by the Bureau's Seattle Pathology Laboratory. Heretofore, the ease and economy of salt treatments have justified their usage even in the face of doubts as to the permanent efficacy of the treatment and the obvious necessity for repeated administrations to maintain losses of infected fish at a tolerable level.

"Formalin" is the commercial name for a solution of formaldehyde gas in water, the actual strength being from 33 to 40 per cent by weight. The U.S.P. grade of formaldehyde solution, or formalin, likewise contains a small quantity of methyl alcohol. The commercial grade of formalin should be avoided in treating fish. Formalin possesses many desirable characteristics which make it almost ideal as a hatchery therapeutic. Although poisonous to human beings if taken internally and irritating to the skin if applied full strength, dilute concentrations will not injure skin, cloth, fabrics, leather, or colors. Formalin is slightly acid, but not sufficiently so to corrode metals other than iron and steel which may be affected by prolonged exposures. It has a characteristic odor which disappears rapidly upon drying. Most important of all, formalin possesses a much greater margin of safety between a concentration toxic to fish and an effective concentration, at least against *Trichodina* sp., than any other known disinfectant. A 1:4,000 concentration of formalin will completely eradicate all *Trichodina* sp. from trout in a sixty-minute exposure. Healthy trout will tolerate three successive exposures of 120 minutes each to this concentration at three-day intervals with no apparent ill effects.

Formalin was advocated as a disinfectant for the prolonged treatment of fish diseases by Kingsbury and Embody (1932). These authors stated, "Formaldehyde is especially effective in eliminating *Gyrodactylus, Dactylogyrus,* and the protozoan parasites." This statement, insofar as it applies to *Trichodina,* has been confirmed by the controlled infection studies reported herein.

The chief barrier to the use of formalin as a hatchery therapeutic has been the considerable expense involved. Kingsbury and Embody (1932) estimated the cost of treating 20,000 trout in a 2½ per cent salt solution at $0.08 and in formalin, 1:2,500, at $0.43, or a cost

ratio of approximately 5:1 in favor of the salt. This relationship between the cost of salt treatment and prolonged treatment with formalin does hold true for the original method of prolonged treatments. However, in the recirculating technique advocated by Fish (1939), the relative costs are reversed. Based on the same cost for reagents as quoted by Kingsbury and Embody, 100 cubic feet of water could be treated with a $2\frac{1}{2}$ per cent salt solution for \$1.17. The cost of treating 100 cubic feet of water by recirculating a 1:2,500 solution of formalin would be \$1.07; a 1:4,000 solution, \$0.67; and a 1:6,000 solution, \$0.45.

For ordinary prolonged treatments by recirculation, a sixty-minute exposure to a 1:4,000 concentration of formalin is recommended. Under conditions where ample aeration is assured and no danger from increasing water temperature during treatment exists, a 120- to 150-minute exposure to a 1:6,000 concentration of formalin will prove equally effective and considerably less expensive. If the fish have been markedly weakened by disease, a material reduction in the time of exposure is advisable.

## Conclusions

Of the disinfectants tested to date, formalin shows the greatest promise. A sixty-minute prolonged treatment by recirculating a 1:4,000 solution of this reagent, or a 120- to 150-minute treatment with a 1:6,000 concentration, will remove infections of *Trichodina* sp., and presumably other external parasites as well, more effectively, more economically, and with less attendant mortality than will any other method now known.

## Literature Cited

Fish, Frederic F.
1933. The chemical disinfection of trout ponds. Trans. Am. Fish. Soc., Vol. 63, pp. 158-163.
1939. Simplified methods for the prolonged treatment of fish diseases. Trans. Am. Fish. Soc., Vol. 68, 1938, pp. 178-187.

Hess, Walter N.
1930. Control of external fluke parasites on fish. Journal of Parasitology, Vol. 16, pp. 131-136.

Kingsbury, Oliver R. and George C. Embody.
1932. The prevention and control of hatchery diseases by treating the water supply. Special Report, Conservation Commission, State of New York, 16 pp.

---

## Discussion

THE CHAIRMAN: Has Dr. Fish had experience with the use of salt water from the ocean?

DR. FISH: No, I never tried it. I presume the only effect it would have would be the same as a salt concentration.

MR. WALES: I believe some of the Oregon men have tried keeping salmon fingerlings in ocean water and comparing the results with others kept in fresh water, but I do not think California has done anything along that line. Perhaps some of the Oregon people who are here can report on that.

DR. GRIFFITHS: I have not used salt water on *Cyclochaeta*, but I did just recently use quite a lot of salt. One result with salt which I think has been overlooked is that the fish seem to come out of it very easily and start to eat readily; it has a stimulating effect. Salt does not eliminate all the parasites, but if the hatchery man salts fairly regularly he will find that his fish get along quite well. We used salt water once in an attempt to control *Ichthyophthirius*, but did not get any results.

DR. FISH: Our figures may be interesting in that respect. Salt treatment was applied to five fish for one hour in a 3 per cent solution. Ordinarily you cannot do that, but the water temperature was around 40° F. and apparently the fish can stand it much better at this temperature than at a higher temperature. The number of parasites on five fish immediately before treatment was 985. Twenty-four hours after treatment there were 50 parasites present. Where formalin was used in a ratio of 1:2,000, with an exposure of sixty minutes—before treatment there were 1,656 parasites on five fish, and twenty-four hours after treatment there were none. I may say that the fish will tolerate easily a treatment of formalin, 1:2,000, at a water temperature of 45° F., without any undue loss, for as long as four hours.

I was interested to note in the *Daily Oregonian*, on our way down, an article on the use of formalin in another capacity—not necessarily, of course, applicable to fish. It does not stain, it does not injure fabrics, and it is an excellent treatment for "athlete's foot." It appears that it not only helps the fish, but it also helps the fish-culturist.

DR. HUNTER: Will Dr. Fish describe the apparatus for recirculation? I did not quite understand how you accomplished the recirculation of your reagents.

DR. FISH: As a matter of fact the originator of that method is Mr. Charles Foster, of the Washington State Hatchery at South Tacoma. It is very simple; all you do is block off your water supply and use a centrifugal pump to keep the water aerated. It is much easier to use than the old methods of prolonged treatment. It is very simple to figure the volume content in the pond by standard mensuration formulae. You can figure your dilution and then mix it in and spread it around if the pond is large, and start your pump going. This, of course, is a progress report, because we are still working on that method. I have used certain disinfectants (boric acid) as long as two hours—in a standard trough 16 feet long and 14 inches wide, containing about 6 inches of water. It had 6,000 No. 2 silver salmon in it. They stood that treatment with the water cut off completely—no recirculation—for two hours, in a 1:500 solution of boric acid. Eventually I think the technique will need no apparatus at all, if we can figure out how long the fish will stand it safely without depleting the oxygen supply.

DR. HUNTER: Did I understand you to say you have used this solution in troughs?

DR. FISH: The primary purpose of the recirculation method was for application in ponds, although trials were generally made in troughs. I have used it in ponds, and it works very nicely. It is the only effective method which obviates the necessity of seining and handling your fish, which I believe does more damage than the disease would have done if you had left the fish alone.

THE CHAIRMAN: I have noticed that when we had *Ichthyophthirius* on small-mouth bass, it seemed to disappear of its own accord as the water temperature increased. Is it susceptible to that sort of change in temperature?

DR. FISH: In this particular experiment they raised the temperature up to a certain point and held it for a definite length of time, and they maintain it clears up the fish. *Ichthyophthirius* was not involved in this test I was describing. After all, smallmouth bass will stand very warm water. It is quite possible that would work; I do not know. I am not sure that anyone knows the thermal death time, so to speak, of *Ichthyophthirius.*

THE CHAIRMAN: In recirculating the water, instead of using fresh water, did you use water which was simply warmed up? Perhaps it was effective on that basis.

DR. FISH: You are referring to this experiment?

THE CHAIRMAN: Yes.

DR. FISH: No, we kept a temperature record. The temperature rose about 1 degree in two hours.

THE CHAIRMAN: As I recall it, pathogenic bacteria in which we are interested from the standpoint of human disease have been carried through cultures, and it is known that they go through a series of cycle stages, only certain of which are virulent. Have such cultures been made of bacteria that are causing fish diseases, and are they known to go through a series of cycle stages with virulent stages as well?

DR. FISH: As a matter of fact, to my knowledge the only pathogenic organism of fish which you can call that is *Bacterium salmonicida.* Dr. Duff, of the University of British Columbia, has done some work in this connection, on which perhaps Mr. Mottley, who has worked with Dr. Duff, or Dr. Pritchard, could give some information. I do not know what success he had, I merely talked with him. Either Mr. Mottley or Dr. Pritchard could answer the question better than I.

THE CHAIRMAN: I am still thinking in terms of change of temperature. As I recall it, that is one explanation of what brings about these changes in the pathogenic bacteria, and possibly some change in temperature would be effective also in this instance.

DR. FISH: That is quite possible. We know so little about the organism.

# FISH PRODUCTION IN TERRACE-WATER PONDS IN ALABAMA[1]

H. S. Swingle and E. V. Smith

*Alabama Agricultural Experiment Station, Auburn, Alabama*

Abstract

Terrace-water ponds are being constructed in Alabama that have as their only source of water supply the "run off" from terraced pastures and crop lands. The water level in the ponds fluctuates, and a maximum of 2 to 4 feet of water is lost by evaporation and seepage during extremely dry weather. A minimum depth of 10 feet in the deepest part of the pond is recommended in order to carry the fish population through dry periods.

The terrace-water ponds are being used successfully for the production of largemouth black bass, bluegill bream, and crappie. They can be fertilized successfully with commercial fertilizer as very little water is lost over the spillway during the growing season. One such fertilized pond, having a maximum area at high water of 1.5 acres and an average area of approximately 1 acre, was drained after three years; it was fished during the summer prior to draining. A total of 77 pounds of fish was removed by fishing and 580 pounds were taken from the pond when it was drained; of this poundage, 225 pounds were largemouth bass, and 284 pounds were bluegill bream. The remainder consisted of golden shiners and yellow bullheads. In another fertilized pond the catch of game and pan fish in one season was 94 pounds per acre.

---

## Introduction

Fish ponds are being constructed by farmers and sportsmen in Alabama at the rate of several hundred a year. Where possible, water is used from small streams, springs, or artesian wells, but where such sources of water are not available, the "run-off" water from terraced fields or pastures is being utilized. The drainage water from 10 to 30 acres of terraced land is necessary to supply water for each acre of pond. These ponds usually are full only during the winter and early spring months. Between wet periods, their water level gradually falls due to the loss of water from evaporation and seepage. During long dry periods as much as 2 to 4 feet of water may be lost.

In the construction of a terrace-water pond (Swingle, 1938) care must be taken to insure as impervious a dam as possible, as leaks through or under the dam may result in the pond drying up during periods of drought. Top soil on the area to be occupied by the dam must first be removed so that the dam may be anchored into a stratum relatively impervious to water. The dam then must be constructed of soil containing sufficient clay to enable it to be tightly packed. A 2:1 slope on the front and back side of the dam has been found adequate.

---

[1]Published with the approval of the Director.

The maximum depth of water in the pond should be 10 feet or more to insure enough water to carry the fish through long dry periods.

Where a sufficient depth of water has been provided, terrace-water ponds have been used quite successfully as fish ponds. Largemouth black bass, crappie, bluegill bream, and bullheads do very well in these ponds and they furnish excellent fishing where properly managed. Since very little or no water passes out of the pond during the summer, conditions are ideal for the use of commercial fertilizers and a large number of these ponds throughout Alabama are being fertilized to increase their productivity.

### Terrace-Water Ponds at the Sand Mountain Substation[2]

In order to test, on a practical scale, the results of experiments on fish production, two terrace-water ponds were constructed on the Sand Mountain Substation of the Alabama Experiment Station at Crossville, Alabama. These ponds get their water from the terraces on approximately 30 acres of cultivated land, and are totally dependent upon the "run-off" water from this area. The ponds are constructed one above the other, the lower pond receiving only the excess water passing over the spillway of the upper pond.

The upper pond has a maximum area of slightly more than 2 acres, but averages somewhat less than 1.75 acres throughout the growing season of the fish. It was constructed in 1935, and stocked with 17 adult bluegill bream (*Lepomis macrochirus*), 17 adult yellow bullheads (*Ameiurus natalis*), 12 adult golden shiner minnows (*Notemigonus crysoleucas*), 180 fingerling largemouth black bass (*Huro salmoides*), and 11 adult bullfrogs (*Rana catesbiana*).

The lower pond has a maximum area of 1.5 acres, but, due to the gradual water recession during the spring and summer, averages approximately 1 acre throughout the growing season of the fish. It was constructed in January, 1936, and stocked with 2,000 fingerling bluegill bream and an unknown number of yellow bullheads and golden shiners. In August, 1937, five adult largemouth black bass and an unknown number of fingerlings were placed in the pond. In addition to these fish the pond received unknown numbers of fry which passed over the spillway from the upper pond.

### Fertilizer Applied to Ponds

A commercial, mixed fertilizer equivalent to the mixture recommended by Swingle and Smith (1938) was used in these ponds; this consisted of 100 pounds of 6:8:4 (N-P-K) commercial fertilizer plus 10 pounds of nitrate of soda. A total of from 500 to 700 pounds of the mixture was used per acre per season during 1936 and 1937. During 1938, approximately 1,000 to 1,200 pounds were used per

[2]These ponds were constructed and managed by R. C. Christopher, Superintendent.

acre; the larger amounts were made necessary by heavy rains which washed out part of the fertilizer. The cost for fertilizer was approximately $10.00 per acre in 1936 and 1937, and $15.00 per acre in 1938.

## Fishing Records on Two Terrace-Water Ponds

It has been shown (Swingle and Smith, 1939) that commercial fertilizers greatly increased the fish production of ponds by increasing the food available for the fish. Many pond owners, while wishing to fertilize their ponds, have hesitated to do so as they feared that the great increase in food would result in lowering the catch of fish. Fishing results on the ponds at the Sand Mountain Substation indicate that these fears are groundless. These ponds were fished lightly by several families, and the fishing was much better than the actual records indicate as many fish were caught and returned to the water. Only the fish removed and eaten during 1938 are recorded in Table 1.

**TABLE 1. FISH CAUGHT IN TERRACE-WATER PONDS, SAND MOUNTAIN SUBSTATION, CROSSVILLE, ALABAMA, 1938.**

| | Total quantity of fish removed | | | |
|---|---|---|---|---|
| | Upper pond (1.75 acres) | | Lower pond (1 acre) | |
| Species | Number | Weight (pounds) | Number | Weight (pounds) |
| Largemouth black bass | 52 | 85 | 14 | 25 |
| Bluegill bream | 310 | 80 | 164 | 45 |
| Yellow bullhead | 0 | 0 | 11 | 7 |
| Total weight | ---- | 165 | ---- | 77 |
| Total pounds per acre | ---- | 94 | ---- | 77 |

The recorded catch, consisting of bass, bluegills, and bullheads, was 94 pounds per acre in the upper pond and 77 pounds in the lower pond. The low yields were due to the extremely light fishing to which these ponds had been subjected. These catches compare favorably, however, with catches of game and pan fish reported elsewhere. Swingle (1936) reported an average catch in one year of 30 pounds per acre in unfertilized Alabama ponds; Eschmeyer (1935) recorded the catch in Fife Lake, Michigan, as 10 pounds per acre; Viosca (1935) estimated the average catch in Louisiana at 30 pounds per acre; Elkins (1937) reported a catch of from 3 to 9 pounds per acre in Wisconsin lakes; and Hazzard (1935) reported an exceptionally large catch of 38.3 pounds of trout per acre in Fish Lake, Utah.

## Fish Production Records on a Terrace-Water Pond

It appeared that entirely too few fish were being removed from the fertilized ponds at the Sand Mountain Substation for the most efficient utilization of the crop. Therefore, in order to determine exactly how many pounds were being produced, the lower pond was drained in

January, 1939, and all the fish removed, counted, and weighed (Table 2).

**TABLE 2. FISH REMOVED FROM LOWER POND, SAND MOUNTAIN SUBSTATION, CROSSVILLE, ALABAMA, JANUARY, 1939. (AREA OF POND, 1 ACRE)**

| Species | Number | Weight Pounds | Weight Ounces |
|---|---|---|---|
| Golden shiners | 2,353 | 134 | 11 |
| Small bream[1] | 7,880 | 173 | 10 |
| Large bream | 263 | 65 | 6 |
| Small bass[2] | 346 | 76 | 9 |
| Large bass | 76 | 124 | 3 |
| Yellow bullhead | 8 | 5 | 5 |
| Gambusia minnows | 222 | 0 | 4 |
| Total weight | ...... | 580 | 0 |

[1]Under 5 inches in length.
[2]Under 11 inches in length.

A total of 580 pounds of fish was found to be present in this fertilized pond upon draining, and 77 pounds had been removed previously by fishing. A total, therefore, of 657 pounds of fish were removed from this pond which had an average area of approximately 1 acre. Of this total poundage, 522 pounds were game and pan fish and 135 pounds were minnows. The high productivity of this terrace-water pond was due to the proper application of commercial fertilizers. The production of game and pan fish compares very favorably with that reported by workers in other states. Thompson and Bennett (1939) found from 71 to 256 pounds per acre of game and pan fish in Illinois lakes; Juday (1938) found 124 pounds per acre in Lake Wingra, Wisconsin; Smith (1938) reported from 17 to 36 pounds per acre in Nova Scotian lakes; Davis and Wiebe (1930) reported a production of 272 pounds of bluegill bream per acre in fertilized experimental ponds in Iowa. Unfertilized ponds in Alabama have been found to produce from 100 to 200 pounds of fish per acre (Swingle and Smith, 1939).

Of the total of 522 pounds of bass and pan fish removed, 272 pounds were above the legal size limit. Seventy-seven pounds had been removed by fishing, leaving in the pond 195 pounds, most of which should have been removed by fishing if the production were utilized to the best advantage. The large fish were disposed of, and after the pond was refilled, it was stocked with 200 of the small bass and 1,500 of the small bream. Enough small bass remained as a surplus to stock approximately 0.3 acre of fertilized water and enough bream were left to stock 4 acres of fertilized water. The pond was 3 years old when it was drained, and natural reproduction was still sufficiently effective to provide more small fish than were needed in the pond. These results give further evidence that restocking with the species already present in a pond is unnecessary (Swingle and Smith, 1938).

## Literature Cited

Davis, H. S. and A. H. Wiebe.
1930. Experiments in the culture of the black bass and other pondfish. Report, U. S. Commissioner of Fisheries, 1930, Appendix IX, pp. 177-203.

Elkins, Winston A.
1937. A fish yield study for certain lakes in the Chequamegon National Forest. Trans. Am. Fish. Soc., 1936, Vol. 66, pp. 306-312.

Eschmeyer, R. W.
1935. Analysis of the game-fish catch in a Michigan lake. Trans. Am. Fish. Soc., 1935, Vol. 65, pp. 207-223.

Hazzard, A. S.
1935. A preliminary study of an exceptionally productive trout water, Fish Lake, Utah. Trans. Am. Fish. Soc., 1935, Vol. 65, pp. 122-128.

Juday, C.
1938. Fish records for Lake Wingra. Trans. Wis. Acad. Sci., Arts and Let. Vol. XXXI, pp. 533-534.

Smith, M. W.
1938. A preliminary account of the fish populations in certain Nova Scotian lakes. Trans. Am. Fish. Soc., 1937, Vol. 67, pp. 178-183.

Swingle, H. S.
1936. Fish ponds in Alabama. Jour. Ala. Acad. Sci., Vol. 8, p. 27.
1938. Construction of farm ponds. Ala. Agr. Exp. Sta., July, 5 pp. (Mimeographed.)

Swingle, H. S. and E. V. Smith.
1938. Management of farm ponds. Ala. Agr. Exp. Sta., July, 6 pp. (Mimeographed.)
1939. Fertilizers for increasing the natural food for fish in ponds. Trans. Am. Fish. Soc., Vol. 68, 1938, pp. 126-134.

Thompson, D. H. and G. W. Bennett.
1939. Fish management in small artificial lakes. Trans. Fourth North American Wildlife Conference, pp. 311-317.

Viosca, Percy, Jr.
1935. Statistics on the productivity of inland waters: The master key to better fish culture. Trans. Am. Fish. Soc., 1935, Vol. 65, pp. 350-358.

# SAVINGS GEAR IN THE CALIFORNIA DRAG-NET FISHERY

G. H. Clark and S. Ross Hatton

*California Division of Fish and Game, San Francisco, California*

Abstract

The drag-net fishery of California accounts for most of the production of fresh fish for the northern and central California markets. This fishery, which is carried on almost entirely by "paranzella" drag nets, produces about twelve million pounds of fish a year, of which 75 per cent are various flounders that inhabit the waters along the California coast. Because of the tremendous waste of small unmarketable fish, due to the small-sized mesh in the drag nets, an investigation was inaugurated to test the escapement alive of different sized fish through various sizes of mesh, and likewise to measure the effectiveness of the escapement of fish through different parts of both experimental and commercial drag nets. It was found, that by increasing the size of mesh in the sacks or cod-ends of these drag nets, a large percentage of the small unmarketable and immature fish was permitted to escape alive, without reducing the total catch of marketable fish. The drag-net industry in California voluntarily adopted the recommendations for the enlargement of mesh sizes and is now enjoying greater catches per unit of effort.

---

Drag netting or trawling is an old fishery in California. The fishery was started in the 1870's when "good vittles" were at a premium. Trawling began in San Francisco Bay with lateen sail boats and later spread to the open ocean. Power boats were adopted—first steamers, then gasoline and later Diesel-powered vessels were used.

The "paranzella" net is a bottom drag net, somewhat different in design from the more highly developed beam and otter trawl. The net is made in a sack-like form—wide at the mouth and tapering toward the closed end. A lead-line or ground-line is attached to the lower part of the net which forms the U-shaped mouth; a somewhat shorter cork-line or head-rope is attached to the upper part of the mouth of the net in such a manner as to be about 6 feet in advance of the ground-rope in actual operation. All pieces of webbing in the net are either square or oblong in shape. Therefore, all taper and take-up is accomplished by means of hanging to the head and foot ropes and by attachments of one piece of the net to another. All strain of the pull is taken by the head and foot lines directly to the sack proper. This design and construction allows a great deal of "flow" to the wings and at the quarters of the net so that in operation the force of water against the net holds the meshes open.

"Paranzella" fishing is carried on by two boats working together with the net behind and between them on the ocean bottom. Tow or trawl lines, sometimes as long as 1,000 fathoms, lead from each vessel to its side of the net mouth. The two vessels tow about 1,500 feet apart on the same course, thus keeping the wings of the net apart and the mouth of the net open to entrap fish that are in its path.

The nets are fished on an average of two hours for a drag, and usually three drags are made per day. Occasionally enough fish for the day may be taken in two drags; or, if fish are very scarce, four or five drags may be made. The fish are landed on the main fishing boat, sorted as to species, and, for some species, into large and small sizes. All fish that are too small for market, or species that are undesirable, are thrown over the side. Most of these discarded fish are dead.

The catch of the trawl fleet in central and northern California averages one million pounds of fish products per month. Of this amount, 76 per cent by weight consist of some ten species of flounders, of which two species, the pointed-nosed sole (*Parophrys vetulus*) and the round-nosed sole (*Eopsetta jordani*), are of most importance to the fishery. Fourteen per cent of the catch are sharks and skates, 5 per cent rockfish (*Sebastodes*) of several species, 2 per cent Pacific cultus cod (*Ophiodon elongatus*), 1 per cent market crab (*Cancer magister*), and 1 per cent miscellaneous fishes of various species.

In the development of the industry small mesh was used in these nets. However, gradually larger mesh was employed until in 1933 the sack of the net was constructed of 3½-inch mesh (stretched measure; 1¾-inch bar). Observations made on the commercial trawlers six years ago revealed that a high percentage of the catch at sea was of small, unmarketable sizes. These small fish were sorted from the catch by the fishermen and most of them were dead when thrown overboard. It was apparent that the gear being used was wasteful. The possibility suggested itself, therefore, that if the size of mesh were increased, these small fish would escape to grow to marketable size; thus increasing the available population of bottom-dwelling fish. In addition, in the light of investigations in Europe and the eastern coast of the United States, it could even be expected that the enlargement of mesh size might also increase the effectiveness of the gear for large fish.

As a result of the foregoing observations on the destruction of small fish, work was inaugurated to test the escapement of bottom-dwelling fish through various sizes of mesh. Because a high percentage of the catch of trawlers is of two species of flounder, the experiments with different sizes of mesh were designed for these two varieties of fish. A large number of market fish was measured to ascertain their greatest breadth, so that a basis could be obtained as to the proper mesh sizes to test against the mesh size in use on the commercial vessels. It was found that the flounders which were saved from the catch as marketable were just under 5 inches in greatest breadth, and ranged from 205 to 225 millimeters in standard length. At the same time it was also determined that the two species of flounders in question ranged between 205 to 225 millimeters standard length, at first maturity, at an age of 4 years. On the basis of the preliminary findings, experimental drag-net gear was constructed to determine a mesh size that would cause the greatest escapement of fish of these two species

under 230 millimeters standard length, but retain most of the sizes greater than 230 millimeters.

Small otter-trawl nets were constructed with interchangeable cod-ends, so that sacks of various mesh size could be tested on alternate hauls over the same grounds. Some of these trawls were made of small mesh in the wings and throat while others were constructed of larger mesh in the forepart so that tests of the efficiency in the different parts of the net beside the cod-ends could be attempted.

The procedure in the mesh tests was as follows. On a given fishing

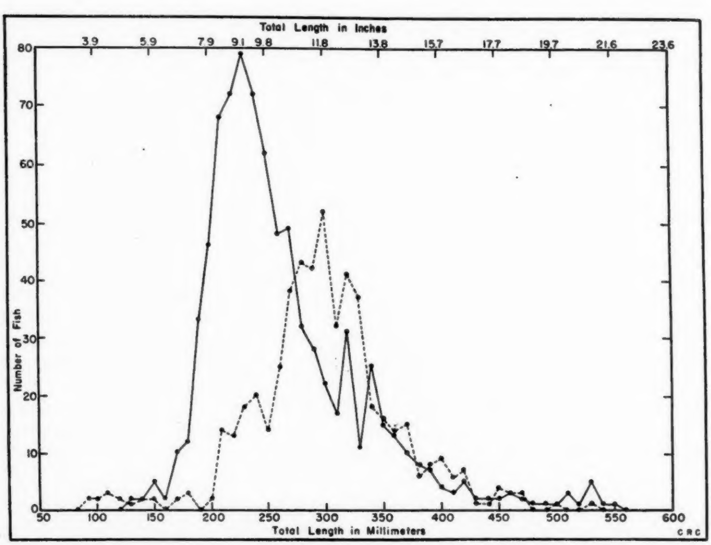


**Figure 1.—Length-frequency distributions of fish (all species combined) captured by experimental trawls with 3½-inch mesh (solid line; 829 fish) and 5-inch mesh (broken line; 523 fish). Combined results of all experimental hauls during the years 1935 to 1937.**

ground a drag was made with a small-mesh otter trawl to ascertain what sizes of fish inhabited that ground. Then alternate hauls were made over the same ground, using different sizes of mesh both in the cod-ends and in the foreparts of the net. Several different grounds were fished over a period of time with different combinations of mesh sizes. In Figure 1 are shown the results of tests with cod-ends of 3½-inch and 5-inch meshes with the experimental otter trawl. The examination of the data revealed that the comparisons between the commercial 3½-inch and the 5-inch meshes were the only ones of importance

because tests made with 4-inch, $4\frac{1}{2}$-inch, 6-inch, and 7-inch stretched meshes indicated that these sizes of mesh were either too small to liberate any number of fish, or too large to hold marketable fish in any quantity. Comparisons between the $3\frac{1}{2}$-inch and the 5-inch mesh show that the use of 5-inch mesh liberates most of the small fish but retains just as many, or perhaps more, of the large fish. The $3\frac{1}{2}$-inch mesh retained 50 per cent and released 50 per cent of the fish at 240 millimeters, while the 50 per cent retention and liberation point of the 5-inch mesh was at 295 millimeters total length.

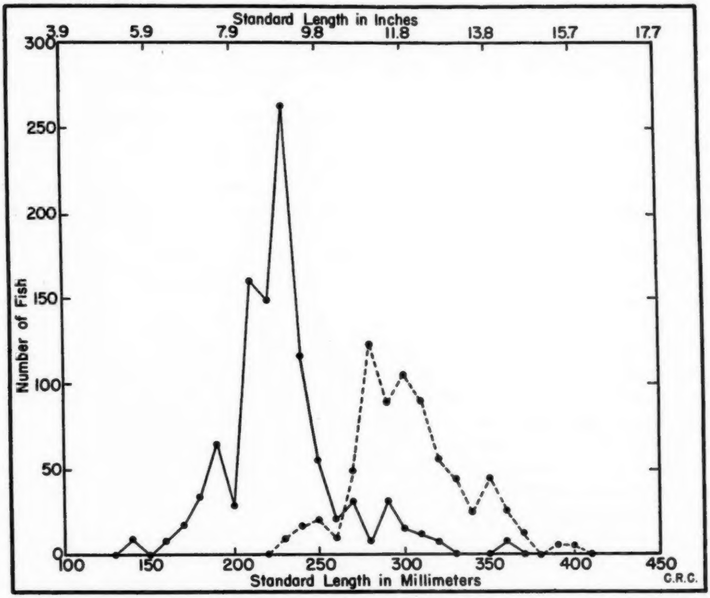


Figure 2.—Length-frequency distributions of pointed-nosed soles captured by a 5-inch mesh commercial paranzella net with a $1\frac{1}{2}$-inch mesh sack (solid line; 1,047 fish) and by a $1\frac{1}{2}$-inch mesh net with a 5-inch mesh sack (broken line; 730 fish). The data are based on the results of hauls made off Eureka Bar, June 25 to July 2, 1937.

The experiments indicated strongly that the escapements of young unmarketable fish in the forepart of the net were equal to, or greater than, in the sack. Although this escapement was not measured accurately, it was nevertheless apparent in all the fishing carried on.

The trawl-fishery industry was informed of the results of these ex-

periments and was urged to try larger meshes in both the sack and forepart of their commercial nets. Members of the industry readily agreed to try an enlargement of the size of mesh in the sacks of their gear, but they were extremely doubtful that any percentage of escapement would occur in the forepart of their commercial "paranzella" nets. However, the industry agreed to aid in making mesh tests on the commercial nets. The Division of Fish and Game furnished three-quarters of the material for special full-sized commercial drag nets, while the industry supplied the balance of the equipment and the labor to construct the gear. These commercial-sized nets were fished from the regular trawler boats during three fishing days and in three localities. The use of the boats, and the services of the fishermen were donated for the work by the fishing companies.

Comparisons of catches made by "paranzella" nets constructed of 1½-inch mesh (stretched measure) in the wings and throat and a 5-inch mesh sack and another net of the reverse construction—a 5-inch mesh forepart and a 1½-inch mesh sack—showed that in commercial-sized nets the escapement apparently occurs almost entirely from the sack (see Figure 2). The net with the large-mesh sack took very few small fish but retained many more large market fish. The 50 per cent retention point for the 5-inch mesh sack was at 292 millimeters, standard length, and the 50 per cent retention point in the 1½-inch mesh sack with large mesh in the forepart was at 222 millimeters, standard length.

As a result of this work the trawl industry in central and northern California in January, 1934, voluntarily cooperated by adopting a 5-inch stretched mesh in the sacks of all commercial nets. Since that time careful observations of the trawl catch and reports of fishermen have demonstrated that with the large mesh there is very little waste of small, unmarketable and immature fish. The fishermen have less sorting to do; they catch less "trash." Even more gratifying is the fact that the catch per drag has increased from 1,625 pounds in 1934 to 1,921 pounds in 1938.

# THREE YEARS OF FISHERIES STATISTICS ON MARINE SPORT FISHING IN CALIFORNIA

RICHARD S. CROKER

*State Fisheries Laboratory*
*California Division of Fish and Game*
*Terminal Island, California*

ABSTRACT

**Since 1936 the California Division of Fish and Game has collected statistics on the ocean sport fishery as a part of its management program. Operators of pleasure fishing boats make out daily reports on the catches of their passengers. Annual catches average 2,000,000 fish with a weight of 6,000,000 pounds. The tabulated reports show: monthly and annual catches of each species; the catch, according to locality, of all species combined and of certain important species; the monthly and annual number of fishermen and number of boat trips; and the number of boats reporting each month and during the year.**

One of the principal outdoor recreations of California is "deep sea fishing." The visitor from inland areas is always eager to try fishing in the ocean, and many of the residents go fishing time and again all season for the excellent sport. But this popularity of marine sport fishing, like so many things in California, has come about suddenly. Twenty years ago there were practically no facilities for ocean sport fishing except skiffs or expensive charter boats. Since then, principally during the last ten years, a fleet of over 200 party fishing boats has sprung up so that now fishermen of small income can avail themselves of the sport. This new fishery has brought its problems, particularly as it competes with the long-established commercial fishing industry for the same fishing grounds and the same kinds of fish. The sport fishery has expanded to the point where facts and figures are required for its proper management. This need has been appreciated, and the Bureau of Marine Fisheries of the California Division of Fish and Game has adjusted its program to include provision for a study of ocean sport fishing. This study is based in large part upon the catch records collected since the inauguration of a statistical system three years ago (Croker, 1937).

As the realization grows that adequate catch records are an essential part of the information necessary in fisheries management, many conservation organizations are planning and inaugurating statistical systems. However, the realization of the necessity and the desire to "do something about it" do not in themselves bring about a complete statistical system ready to function. Careful planning must precede the inauguration of any proposed system. In some situations the expense involved outweighs the necessity—when fishing is light there is no need for an elaborate statistical program. If the fishery warrants the installation of a program—as our ocean fishery does—we must not

only carry on trials along original lines but must also make a study of the successes and failures of other organizations in obtaining catch records. If all organizations engaged in this type of work make their methods known, a considerable amount of wasted effort can be avoided. It is the purpose of this paper to present the methods and results of the work of the California Division of Fish and Game in one phase of fisheries statistics, not as a model of perfection but as an example of what can be expected from one of several possible ways of obtaining catch records.

The first fisheries statistical program in California consisted of the system for collecting records of the commercial fishing industry, inaugurated more than twenty years ago. The system functions so smoothly now that we have all but forgotten the difficulties attending its establishment, and the industry accepts record-keeping as a matter of course. The manifold program for gathering statistics on sport fishing, including the ocean fishery, is much more recent and its various phases are as yet scarcely out of the formative stage. This program follows two general lines—the extensive survey which involves the use of a questionnaire embodied in the application for a license, and the intensive studies on certain bodies of water. In addition to the survey of ocean fishing boats, these investigations include creel-census studies on selected streams and lakes, and the collection of records from the operators of party fishing boats and skiff resorts on certain important lakes and rivers as well as on San Francisco Bay. This varied program is too large to describe in one paper. Consequently this discussion will be limited to our study of the spectacular ocean fishery in which the annual capture of two million fish is involved.

Conditions in California make a study of marine angling catches comparatively easy, but because of the specialized nature of our fishery the only localities in which our methods may find application would be along the Atlantic Coast and in the Gulf of Mexico. Fishing from commercially operated passenger boats accounts for the great bulk of the fish caught by ocean anglers in California. Such a large proportion of the catch is made by the boat fishermen that we decided to concentrate on their activities and thus simplify the procedure. The passenger boats are of three general types: party boats running on regular daily schedule; charter boats operating irregularly; and barges anchored offshore. The party boats are also known as "open" boats—anyone can purchase a ticket which costs $2.00 to $5.00 for a day's fishing. If a group wishes to fish by themselves they obtain a charter boat for $20.00 to $60.00 a day. The barges are mostly old dismasted sailing vessels with shore-to-boat service. Barge tickets, including transportation, cost about $1.00. There is, of course, considerable fishing from private yachts and from piers as well as from rocks and sandy beaches, but the combined catches of shore and yacht fishermen in no way compare with those of the passenger-boat fishermen throughout the greater part of the State.

In laying out the program for collecting records from the passenger fishing boats, we drew heavily on the experience gained in conducting the study of commercial fish catches. When the preliminary work on the catch of sport fishermen was started in 1932 there was no law requiring party boats to keep records, such as had enabled us to obtain records from fish markets and canneries. Consequently, we attempted to obtain voluntary reports (Clark, 1934; Clark and Croker, 1933), and had enough success to enable us to lay the groundwork for a full-fledged program to be started as soon as a law could be passed. This law, requiring operators of passenger fishing boats to take out permits and keep catch records, was passed by the 1935 session of the State Legislature. On January 1, 1936, the boatmen commenced making out daily catch reports under the terms of the new law. In the earlier work we found we could not depend on voluntary reports to give us a complete picture of conditions. The work involved was too much to expect unless it was actually required by law. Even with a law to support the program, it is not always easy to convince the boat operator of the desirability of good reports, and frequently diplomacy is necessary and once in a long while an arrest must be made. However, most of the boatmen keep their records conscientiously. In 1936, we received reports on an estimated 80 per cent of the catches. The percentage increased to about 90 per cent the next year and since then our records have been at least 95 per cent complete.

The system for collecting reports is simple enough. The operator of each boat is given a record book containing 150 serially numbered, perforated pages with spaces for the desired information—one page for each daily trip (only one or two boats make occasional trips lasting more than one day). The sheets are 4 by 8 inches in order that they may fit the same files as our commercial records. During the return trip from the fishing grounds the skipper or a member of the crew fills in the blanks on the sheet, noting the number of fishermen, the locality of catch and the number and weight of each species of fish caught, in addition to the name and number of the boat and the port of landing.

Several methods are used for estimating the size of catch. Usually the report is an approximation based on the observations of the crew members, who can estimate with considerable accuracy. On many boats the individual catches are actually counted; this procedure is easy on those boats where the crews clean the fish. The weights are usually based on estimated averages which are quite accurate. On the large barges, with sometimes as many as 300 passengers coming and going during a day, accurate estimates are more difficult than on the smaller boats. Although a few boatmen may be inaccurate or even deliberately falsify their records, we believe that practically all the reports are sufficiently reliable. In any event the errors that do occur are of a compensating nature and tend to balance each other when summaries are made.

The record sheets are either picked up at monthly intervals by our

field man or are mailed to us in special business reply envelopes. We prefer to receive them by mail, but we find that visiting the operators at frequent intervals to collect records reminds them of their responsibility and that better reports result. New books are given out, either personally or by mail, when the need arises.

Our experience has shown us the desirability of having on the record sheet a list of the species likely to be caught. If the list is not given the boatman is apt to write in only the larger game fish and neglect the small species. The first books we had printed were intended for statewide use and included twenty-six kinds of fish. The selection of the list was influenced by our preliminary work of 1932; the list included, therefore, the more important species taken in southern California where the variety is greater than farther north. Additional experience showed that some species were not important enough to warrant inclusion, but that others should be added. The second printing had spaces for twenty-seven species. Then we found that this long list was causing confusion in central California where fewer species enter into the catch. Accordingly we now have two different forms—one with fourteen kinds of fish for central California and one similar to the original, carrying twenty-five species, for the more diversified fishery of southern California. In addition to the lines with names there are several blank lines which the skipper can use for additional species that are caught only infrequently.

With minor exceptions the system is now functioning smoothly. Reports are kept by nearly all the operators as a matter of course, and much less field work is necessary now than two years ago. All the big outfits that operate fleets of boats are very good about keeping records. The manager simply orders his crews to comply and they do. The one-boat operators who run on regular schedule are very nearly as reliable, although some of them become careless occasionally. The greatest difficulty is encountered with the owners of the charter boats who operate irregularly, principally on week-ends. Most of them are conscientious but many simply do not remember. Some deliberately fail to make out reports and others, not being primarily fishermen, do not realize the importance of our study and are careless. Collecting the few records from several dozen neglectful operators by mail and in person requires nearly as much time as collecting thousands of reports from the regular party boats and barges and the conscientious operators of charter boats. We have found that records are most difficult to obtain at the beginning and end of the season. The season is approximately the same along the entire coast—April to September, with only a few boats operating from October to March. Many of the skippers forget to report their first few trips in the spring, especially when fishing is poor. With the cessation of fishing in the fall, most of the boatmen scatter inland or leave on commercial fishing trips. Consequently it is difficult to locate either them or their last few records.

Before tabulation, the record sheets are carefully checked by the field

man to detect such errors as transposed numbers in the locality of catch, errors in dates, or figures on the wrong line.

The records are tabulated by the statistical department of the California State Fisheries Laboratory, using the Hollerith punch-card system by which all California fish and game statistics are compiled. By the use of this system, a great variety of summaries can be produced with a minimum of effort. The reports on marine sport catches show the following facts: monthly and annual catches of each species (by number of fish and weight); the locality of catch of all species combined and of certain important species; the monthly and annual number of fishermen and number of boat trips, along with the amount of fish caught; and the number of boats reporting each month and during the year. Summaries are prepared for fishing regions as well as for the entire state. The state was divided into geographical regions for the commercial fisheries program, and the same regions are equally well suited to the sport fisheries program. There is no passenger-boat fishing in northern California. Consequently the reports on sport catches are confined to the coastal regions of central and southern California: San Francisco, Monterey, San Luis Obispo-Ventura, Los Angeles, and San Diego. The reports of the catches of anchored barges and of mobile boats are also separated. Some of the boat operators fail to report the number of fishermen because they do not realize the importance of that information. Consequently, the reports showing the number of trips must be separated, one set of figures including those trips when the number of fishermen was reported and the other including trips where that information was not given.

From the reports we can calculate not only the total catches of each species, but the landings at different ports, the catches on the various fishing grounds, monthly and annual trends, and the catch per unit of effort. This study is not purely biological. Our results show the importance of sport fishing in relation to other phases of outdoor recreation and wildlife utilization, as evidenced by the number of boats and fishermen participating and the quantities of fish caught. One disturbing feature is that nearly all of the boats fish for any kind of fish that is to be had rather than for just one species. Consequently, a catch analysis of any one species is very complicated. We will have to use considerable care in the selection of boats, seasons and localities, and in any event will probably have to combine the fish into groups of species.

We now have three years of statistics on ocean sport fishing. The data for 1936 and 1937 have been tabulated and subjected to preliminary analysis. The 1938 reports are now being tabulated. The program is being continued and 1939 records are coming in daily.

The reports for the first two years bring to light some interesting facts—some of them surprising, others already suspected after the analysis of the first incomplete voluntary returns. Total catches reach very respectable figures. The reported catch for 1936 was 1,960,000

fish that weighed 6,360,000 pounds. The following year the reported catch was 2,130,000 fish that weighed 6,400,000 pounds. The 1937 figure represents the catches of 328,000 man-days, or 14,000 boat trips. A total of 220 boats reported their activities that year. A brief discussion will give some idea of the kind of facts that can be determined from reports of the sport catch.

Southern California is far more important than central California in the marine sport fishery. There are at least four reasons for this situation: a larger population near the coast; more ocean game fish; more pleasant weather along with a smoother ocean; and less inland fishing facilities. The Los Angeles region, comprising Los Angeles and Orange counties, ranks first among the regions, with 75 per cent of all the fishermen reported in 1936 and 1937 and 72 per cent of the tonnage caught. Practically all the fishing in this region takes place off the coasts of Los Angeles and Orange counties, with some catches made off northern San Diego County. The three most important sport fishing grounds in the state are in this region: Horseshoe Kelp off San Pedro, Santa Monica Bay and Santa Catalina Island. Twenty per cent of the catch of the entire state during these years was caught on the one small fishing area known as Horseshoe Kelp-Huntington Beach Flats. Another southern California region, San Diego, is second in importance, with 16 per cent of the anglers and 22 per cent of the catch. Most of the fishing here is done at Los Coronados Islands, just below the Mexican border, but there is also considerable fishing along the San Diego County coast. The Monterey region, with fishing carried on in Monterey Bay, is next, followed by the San Luis Obispo-Santa Barbara-Ventura region, with most of the fishing off San Luis

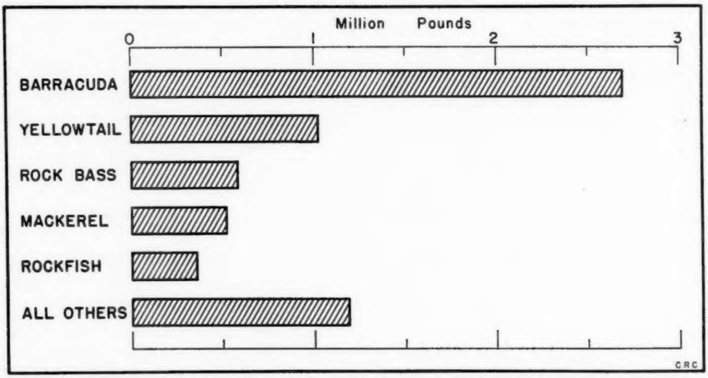


Figure 1.—Average annual catch in pounds, 1936-1937, of the five most important kinds of fish reported caught on the party boats and barges operating off the coast of California.

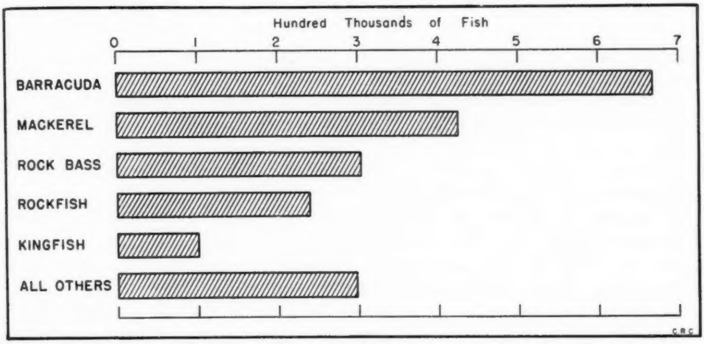


**Figure 2.—Numbers of fish reported caught on the party boats and barges operating off the coast of California. Average annual catch, 1936-1937.**

Obispo County. The San Francisco region, embracing the ocean waters of Marin, San Francisco and San Mateo Counties, is of negligible importance.

Of all the species of fish taken by ocean anglers, the barracuda (*Sphyraena argentea*) is most important (see Figures 1 and 2). This southern California game fish comprises 42 per cent of the total catch by weight. In the Los Angeles region the success of the entire fishing season depends on the barracuda run. Next in importance is the yellowtail (*Seriola dorsalis*), which accounts for 16 per cent of the catch. The greater part of the catch of this species is made at Los Coronados; the success of the season at San Diego is judged almost entirely on the size of the yellowtail run. Third, with 9 per cent, is another southern California game fish, the rock bass (mostly *Paralabrax clathratus,* with some *P. nebulifer*). The mackerel (*Pneumatophorus diego*), taken principally in southern California, comprises 8 per cent of the total. The various species of *Sebastodes,* known as rockfish, rank fifth with 6 per cent. Most of the rockfish catch is made in central California. The above five kinds of fish accounted for 81 per cent of the ocean sport catch in 1936 and 1937. Other desirable game fishes, such as halibut, bonito, tuna, marlin, white sea-bass, salmon and cultus are taken in lesser quantities, along with a miscellany of small fishes, sharks and rays.

The figures already given show what sort of totals can be compiled from this type of study. From them the administrator can determine what regions, fishing areas, species of fish and seasons are most important to the sportsman, and if protective legislation is necessary this knowledge is of decided significance.

The program has not been under way long enough to show changes in the abundance or availability of fish. However, determinations of

the catch per unit of effort have been made, using one man's catch for one day as the unit. The catch per man-day in the three northernmost regions was about the same in 1937 as in 1936: 24 pounds at San Francisco, 13 pounds at Monterey and 20 pounds in the San Luis Obispo-Ventura region. In the two southern California regions, catches dropped off in 1937. Catches on the mobile boats in the Los Angeles region fell off from 33 pounds per man-day to 25 pounds, and San Diego catches likewise dropped from 33 to 25 pounds. Barge catches in the Los Angeles region, however, improved slightly from $8\frac{1}{2}$ pounds a day to 10 pounds. Although average catches in the Monterey region are the poorest with respect to the pounds of fish taken per day, the catches in this area are relatively good if the numbers of fish, instead of weights, are considered. Most of the fish are small at Monterey, and the catches average about eleven fish a day. The largest fish of all are taken at San Diego, and although catches are very high according to weight, the number of fish per day is low—four fish to the man. It must be remembered that these are crude figures from unselected boats, but they are indicative of fishing conditions.

Finally, our reports give us a basis for comparing pleasure and commercial fishing. Nearly all of the leading sport fishes are also of importance to the fishing industry, and frequently conflicts arise between the two factions in the fishery. With virtually complete reports on the catches of both angler and market fisherman, we are in a better position to judge which of the two groups exploits any particular fish more, and to which the fish is more useful. With these figures available, compromises and a settlement of controversies may be possible.

## Literature Cited

Clark, G. H.
1934. The need for a measure of the angler's catch. Trans. Am. Fish. Soc., Vol. 64, pp. 49-53.

Clark, G. H., and Richard S. Croker.
1933. A method of collecting statistics of marine sport catches in California. Trans. Am. Fish. Soc., Vol. 63, pp. 332-337.

Croker, Richard S.
1937. How California is measuring the angler's catch. Trans. Am. Fish. Soc., Vol. 66, pp. 301-305.

---

## Discussion

THE CHAIRMAN: The fisherman is compelled by law to keep records. Do you supply him with copies of your reports after you have them compiled so that he can see the value of these records?

MR. CROKER: We have not published any report as yet, but we are doing so this year and every boatman will be given a copy of it. I may say, however, that they are all familiar with the general significance of the reports.

# SMALLMOUTH BLACK BASS PROPAGATION IN CALIFORNIA

MERRILL W. BROWN

*Foreman, Central Valleys Bass Hatchery, Elk Grove, California*

ABSTRACT

This paper traces very briefly the history of the smallmouth black bass in the State of California from the time of its introduction to the present day. The Central Valleys Bass Hatchery, recently constructed near Sacramento, California, is described. Methods and results of the propagation of smallmouth black bass are reviewed in an account of the operations in the 1938 season at this new California bass hatchery.

---

The purpose of this paper is to present the history and methods of smallmouth black bass propagation in California. This species of fish is not native to California waters but was introduced, along with other spiny-rayed fishes, during the latter part of the last century. Seemingly, at that time, the largemouth and the smallmouth bass were frequently "grouped" together in the planting records and reports under the term, black bass. However, the records do indicate that the smallmouth was the first to be introduced and was probably brought to California in 1874 by Livingston Stone. This first plant was distributed in Napa and Alameda Creeks. The introduction of these fish met with considerable success and their distribution soon became widespread in the state.

The popularity of the smallmouth bass as a game fish grew rapidly, and constant and repeated requests were received by the Bureau of Fish Conservation for plantings in various rivers, lakes and ponds. Accordingly artificial propagation was first undertaken in 1933 when an experimental bass hatchery was constructed at the town of Friant, near the city of Fresno. Here it was demonstrated that these fish could be propagated successfully, and that they could be transported long distances and planted without loss. Accordingly, a permanent plant was constructed at the town of Elk Grove, 15 miles from Sacramento.

This new hatchery, as shown by Figure 1, covers an area of nearly 25 acres and has, besides the various ponds, two residences, a combination office and laboratory, a shelter for nets, a warehouse, a fertilizer shed, a pump house and a garage. The ponds are divided as follows: one 1½-acre spawning pond; twelve ½-acre rearing ponds; four ¼-acre rearing ponds; and a series of seventeen cement daphnia tanks, each 1,000 square feet in area and located so that they drain into the rearing ponds.

Our water supply comes from a deep well and is pumped directly into the various ponds through underground pipes. It might be well to mention that all ponds are so constructed that each can be operated as a unit and may be drained or filled independently.

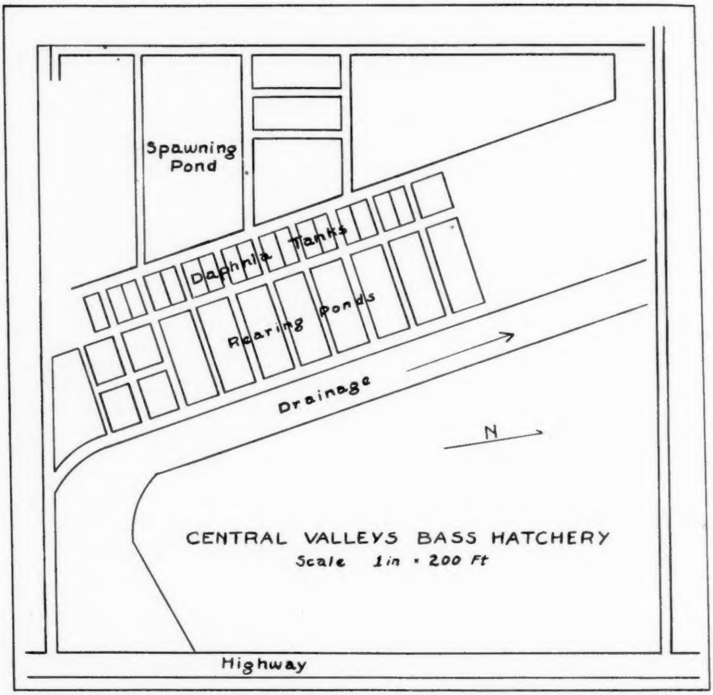


Figure 1.—Plan of the Central Valleys Bass Hatchery.

The progress of smallmouth black bass propagation in this state can probably be most successfully reviewed by presenting the methods used and the results obtained in 1938, our first year of operation at the Central Valleys Bass Hatchery.

All of our brood fish were obtained during the summer and fall of 1937 by seining and by hook and line. These fish were kept in the spawning pond, which also serves as a brood-fish holding pond, and were constantly supplied with forage fish such as hardhead minnows, Sacramento suckers, mosquito fish and the like. Forage fish are readily obtained by netting in the irrigation ditches located throughout the central valleys of California. In mid-March the spawning pond was drained, all forage fish removed and the bass examined. Two hundred twenty adult spawners were on hand.

As water temperatures approached the spawning temperature careful watch was kept of the pond; the first egg deposit was found on

March 31. At that time the water temperatures were rising rapidly and averaged 56° F. During the breeding season there were three distinct spawnings, and as the season advanced it was noticed that the nests at each successive spawning became less numerous and contained fewer eggs per individual nest. Furthermore, the survival of the eggs was lower in the later nests. Whereas the bass spawned the first group of eggs on a rising temperature it was readily observed, by the comparison of temperature and nest charts, that the second and third spawnings took place during a decided drop in the water temperatures. However, the spawning of the second and third group began at a little higher temperature than that at which the first spawning had begun. The season was completed in about six weeks, the last nest being located on May 13. Of 186 nests on which eggs were found, 154 had successful hatches.

Fry appeared for the first time over the nests on April 8, just nine days after spawning. The average time for the early group of egg deposits to appear as fry was seven days. For the second group five and one-half days was the average and for the third and last grouping, four days. Water temperatures particularly appeared to govern the incubation period. However, the time between the appearance of the fry and when the fish rose from the nest, averaged ten days and remained the same throughout the season in spite of rising water temperatures.

The bass fry were netted by means of bobbinet seines from the open, saucer-shaped gravel nests, placed in wash tubs and transferred to the various rearing ponds. The counting of these young bass into the rearing ponds was accomplished by means of weighing with a triple-beam balance. It was found that the fish weighed approximately sixty to the gram when brought over from the spawning pond. They averaged 10 millimeters in length.

The first fry were netted and transferred to the rearing ponds on April 19. After that date these ponds were stocked as rapidly as possible at the rate of 50,000 to the acre until May 10, at which time the final transfer from the spawning pond was made. A total of 231,121 smallmouth black bass fry was placed in the various rearing pools during the three-weeks spawning period.

*Daphnia* and related forms as a source of food for the young fish are produced at the Central Valleys Bass Hatchery in cement "*Daphnia* tanks" and in the rearing ponds. Soybean meal mixed three parts to one with acid phosphate, made into a mash and allowed to sour, was the only fertilizer used for the production of bass food. The fertilization of the rearing ponds and the *Daphnia* tanks with the sour mash was so planned that a continuous supply of food was always on hand for the young fish. About twenty days in advance of the first transfer of fry, the ponds into which the early fish were to be planted were each fertilized with the soybean meal mash. As the season advanced the remaining ponds and then the *Daphnia* tanks were set up and inocu-

lated with Crustacea. To avoid any possibility of pollution, the rearing ponds were fertilized only once at the beginning of the season by scattering 350 pounds of the soybean meal and acid phosphate around the shallow edges. Fifty pounds of mash were used in each of the *Daphnia* tanks, which were set up in rotation so that the peaks of production would not all come at once. This procedure, of course, assured a continuous supply of food for the bass. Each *Daphnia* tank was drained into the rearing ponds every eight days. The most common cladoceran form developed here in the hot, interior valley weather belonged to the genus *Moina*. *Daphnia magna* and a representative of the genus *Simocephalus* were also cultured. As water temperatures rose, the production of Crustacea dropped, but fortunately other and larger forms put in their appearance at about that time. Most numerous among these was the bloodworm of the genus *Chironomus*. The cases or tubes of these midge-fly larvae covered the bottom of the *Daphnia* tanks. This food supply was washed down to the bass fry with a pressure hose each time one of the cement tanks was emptied.

Numerous obstacles were encountered during the 1938 season, of which high temperatures and filamentous algae were the most difficult to overcome. Predaceous insects were, of course, found in the hatchery ponds but never were exceptionally numerous. Back-swimmers, of the genus *Notonecta,* were readily controlled by a routine spraying of rearing ponds with cod-liver oil mixed with two parts of gasoline. This regular treatment of the ponds also prevented the tiger-beetle larvae of the genus *Dytiscus* from becoming dangerously common. For control of such predators as the dragonfly nymphs all of the rearing ponds were completely drained at the end of the season, harrowed and allowed to remain empty for several weeks.

Bull frogs which are quite common in all of our ponds have been observed feeding on young fish. However, stomach examinations revealed that dytiscid beetles constituted their principal diet and that comparatively few fry or fingerlings had been taken. The bull-frog tadpoles were the trouble-makers due to the fact that they congregated in the collecting kettles with the fingerlings when the ponds were drained. For this reason the hatchery crew combined business with pleasure and held frequent frog hunts. These evening forays kept the frog population under control.

The immense schools of toad tadpoles which appeared in all ponds shortly after the transfer of the bass fry from the spawning pond offered a much more serious problem. They could be seen by the thousands swimming in a more or less orderly fashion along the edge of the levees. The examination of their stomachs showed that they competed with the young bass for food. Their digestive tracts were jammed with Crustacea. Seines, dip-nets and traps were used in an attempt to rid the ponds of the tadpoles, but to little avail, as young smallmouth bass also were caught in the nets and traps. Fortunately the metamorphosis of the toad tadpoles takes place early in the season and they

had disappeared from the ponds before the harvesting of the fish crop took place.

Fish-eating birds create a problem in that they are protected by law because of their economic or esthetic worth, while on the other hand they are a definite menace to fish-hatchery production. The following birds, named in order of their destructiveness, took their toll from the spawning pond: the great blue heron, the California egret, the black-crested night heron. The Foster tern, the Anthony's green heron, and the western belted kingfisher were the invaders of the rearing ponds. These birds are also listed in the order of their menace to fish life.

Water snakes are common in this section but no bass fry have ever been found in their stomachs.

Vegetation in our bass ponds has proven to be both a blessing and a curse. It is beneficial in that it serves definitely to reduce high water temperatures in a locality where the thermometer frequently climbs to 90° F. or higher. However, vegetation combined with the high air temperatures, when the ponds were being drained, was a death trap to the fish, and it was absolutely necessary to remove this growth by the use of scythes and rakes.

*Spirogyra* and *Hydrodictyon* were the two forms of algae that created the most serious menace in the hatchery. The growths of these forms combined with the heat made the draining of the ponds, at times, almost impossible. Copper sulphate was used in an attempt to control the growth, but to no avail. Some of the algal growth was dipped out of the ponds by the use of long-handled paddles made of wire netting, but the only effective solution was to allow the ponds to drain very slowly, thus permitting the young fry to work out of the algae and into the deeper water.

The one disease organism that appeared on the fish at the Central Valleys Hatchery in 1938 was *Ichthyophthirius,* which was found on some bass fingerlings that had been crowded into a small cement tank after having been picked up from the collecting kettle of one of the rearing ponds. These fish were bathed in a 3 per cent salt solution and then planted.

**TABLE 1. SUMMARY OF REARING POND DATA**

| Pond No. | Number of fish stocked | Age when removed (days) | Number of fish to the ounce | Number of ounces | Total number of fish[1] | Percentage return |
|---|---|---|---|---|---|---|
| 1B } 2B } | 28,491 | 58 | 18.5 | 883 | 16,159 | 57.0 |
| 3 | 25,529 | 77 | 13.0 | 1,158 | 15,054 | 59.0 |
| 4 | 25,337 | 76 | 12.4 | 1,580 | 19,592 | 77.0 |
| 5 | 24,929 | 78 | 16.1 | 1,084 | 17,453 | 70.0 |
| 6 | 25,670 | 78 | 20.8 | 712 | 14,810 | 56.1 |
| 7 | 25,037 | 80 | 7.3 | 1,326 | 9,680 | 38.7 |
| 8 | 25,749 | 79 | 4.7 | 1,428 | 6,712 | 26.0 |
| 9 | 25,233 | 85 | 17.0 | 768 | 13,056 | 52.0 |
| 9A | 25,146 | 79 | 4.4 | 701 | 3,084 | 12.0 |

[1]Grand total—115,600 smallmouth bass.

The returns obtained from the various rearing ponds can, I believe, be best shown by Table 1.

An examination of the summary shows that we harvested a total of 115,600 bass fingerling, which was almost exactly a 50 per cent survival of the original number transferred from the spawning pond. These fish were reared in the ten ponds constituting a total of 5 acres. The average production was therefore 23,150 fingerlings to the acre. In from eight to ten weeks the fish ranged in weight from 4.4 to 20.8 to the ounce, with 11.6 to the ounce being the average weight.

The propagation of smallmouth black bass has not yet passed beyond the experimental stage nor will it be considered more than experimental until it has been demonstrated that propagation and distribution can be successful to the extent that the expense involved is justified. We believe that a thoughtless scattering of fish throughout the state is not a wise policy. The bass reared at the Central Valleys Bass Hatchery are now being introduced into waters that have previously been carefully surveyed, where ''follow-up'' reports can be obtained on the results of the plant and also where the introduction of this exotic species will not constitute an usurpation of the waters of the native trout.

---

## Discussion

The President: Seldom have I heard of such excellent results having been obtained in smallmouth bass culture. Perhaps I may ask a question or two. Do I understand you to say that castor oil and kerosene were used in the control of surface beetles?

Mr. Brown: Cod liver oil.

The President: That was not detrimental to the bullfrog?

Mr. Brown: No.

The President: Did you observe any effect on mosquito larvae?

Mr. Brown: No, although I presume it did kill off the larvae.

The President: We have had numerous complaints in various sections, including the state of Washington, with regard to the presumed destruction of the bullfrog by mosquito-control crews using oil. We feel that if cod-liver oil and kerosene would control the mosquito effectively without injuring or driving out the bullfrog, it would be of considerable benefit in those sections.

Mr. Brown: When we applied the mixture of cod-liver oil and gasoline we tried to do the spraying on calm, hot days. However, at our hatchery at Elk Grove, where there is a prevailing northwest wind, it is difficult at times to wait until there is a calm day on which this can be done. As a rule when we spray a mixture of oil it lasts but a very short time, and flows off to one side. I do not believe it would remain on the surface of the pond long enough to do harm to bullfrogs, or perhaps mosquito larvae either.

The President: There is an opportunity there for investigation; we might be able to save some bullfrogs. Did you use sodium arsenite to control aquatic vegetation?

Mr. Brown: No. I am using that this year for the first time.

# ANGLERS' CATCH RECORDS IN CALIFORNIA

BRIAN CURTIS

*California Division of Fish and Game, Sacramento*

ABSTRACT

California has had in operation for three years a system whereby the angler is requested to make on his application for an angling license a voluntary record of the number of fish which he caught the preceding year, listed by species and by county in which they were caught.

From 75,000 to 90,000 anglers have reported annually, a three-year average of about 27 per cent of the licensees.

Improvements have been made in the system as the need for them became apparent, the most important one having been the operation of a "Second Call" questionnaire in 1938 to sample the make-up and activities of the non-reporting portion of the angling population.

The data having to do with numbers of anglers, as for instance, the number who report fishing for each species, may be considered to have a high degree of reliability.

The data having to do with numbers of fish caught, as for instance, the total reported catch of any species, are of uncertain reliability. However, comparison of the figures from year to year suggests that considerable confidence can be placed in the results.

Estimates are also made of the activities of the non-reporting part of the angling population, based on the records of those who do report. These estimates are corrected from time to time as new and hitherto unmeasured factors are brought into the picture. These estimates compare satisfactorily from year to year in order of magnitude.

Disadvantages and uncertainties of the system are listed, the outstanding one being the difficulty of determining the extent to which the records of the reporting anglers form a true representation of the activities of the non-reporting anglers.

A method of direct sampling of the angling population is in the experimental stage, which, it is hoped, will eliminate some of the defects in the present system.

The voluntary system is compared with the mandatory system. The weakness of the former is found to be the uncertainty as to whether the records truly represent the non-reporting population; of the latter, the uncertainty as to the reliability of records obtained under legal compulsion from possibly unwilling participants, and also, the difficulty of enforcement.

## INTRODUCTION

This paper describes the work of the Bureau of Fish Conservation of the State of California's Division of Fish and Game with respect to the measurement of the anglers' catch. It discusses principally the methods used, the utility of the results, and the advantages, drawbacks. and possible improvements—all of which are of general interest—and deals with the actual figures obtained only by way of illustration.

The principal forms of catch records kept by the Division of Fish and Game are:

1. Records of the commercial catch, kept by the Bureau of Marine

Fisheries since 1916, obtained from commercial fish dealers who are required by law to make reports.

2. Records of the ocean catch of sport fishermen, kept by the Bureau of Marine Fisheries since 1936, obtained from barge and party-boat operators, who are required by law to make reports of the fish taken by their customers. These records do not include ocean sport fish caught from shore or from private boats. They do include, for reasons which do not concern us here, a part of the striped bass catch in inland tidal waters.

3. Records, kept since 1935 by the Bureau of Fish Conservation, of the game fish caught each year by individual sportsmen, obtained from their voluntary reports. These include both ocean and fresh-water catches.

This paper deals only with records in the last category. It has nothing to do with creel censuses. Creel censuses are of recognized importance, and are being carried on in various parts of the state, but have no direct relation to the work described here.

## Methods

The primary source of the angler's catch data consists of an individual voluntary report. Each year, when he purchases his fishing license, the angler must file an application, and this application form contains, among other things, a request for a record of his previous season's catch. The names of the fish are printed in tabular form, and the angler is asked to fill in the number of each kind caught and the county in which they were taken.

Because the submission of catch records is purely voluntary, many anglers neglect to supply the information. During the three-year period, 1936 to 1938 inclusive, an average of 318,000 licenses per year were issued, and an average of 85,000 licensees (27 per cent) reported their previous season's catch on their applications for a new license.

All license applications are sent to the California State Fisheries Laboratory at Terminal Island in Los Angeles Harbor. Those without catch records are set aside and grouped by county of residence for use in determining the geographical distribution of the whole angling population. The catch records are analyzed and summarized by sorting and tabulating machines.

The final step is the condensation, analysis and interpretation of these tables of data to produce a finished product—a report sufficiently concise and yet sufficiently complete to be of use in the administration of the fisheries. It contains the reported figures showing the total catch of each species, and the catch of each species in each county; the total number of licensees who fish for each species, and the distribution of these men by county of residence. It shows how many anglers go from each county of residence to other counties to do their fishing; and for certain species of particular interest, like trout, it carries much more complete detail, such as the number of anglers from each

county of residence who fish in each county of catch, and the number of fish they catch there. It shows, for instance, that in 1936, out of the 2,465 anglers who reported catching 212,443 trout in Mono County, 1,576 came from Los Angeles County and caught 107,212 trout there.

In addition to the above, which are merely exact summaries of the individual records, the attempt is made to furnish an estimate of the total number of trout caught during each year, based on the reported figures.

### Nature of the Results

From 75,000 to 90,000 anglers reported each year, averaging from 25 per cent to 30 per cent of all licensees. Compared with published reports of other voluntary records, this is a high ratio, and if it were a true random sample, no statistician could ask for more data. A true random sample would give an exact picture, in miniature, of the whole angling population, and from it the total catch of all anglers, and the distribution of the catch, could be computed with a high degree of accuracy. However, it can not be looked upon as a true random sample for the following reasons:

1. Uncertainty as to whether the population of non-reporting anglers has the same make-up as the population of reporting anglers—the "validity of the sample."
2. Uncertainty as to the accuracy of the individual angler's catch record—the "reliability of the unit."

The "validity of the sample" is called into question on four counts.

a. The intensity of reporting varies in different counties. This means that the summation of the individual catch records gives a distorted picture. For instance, the reported catch of trout in 1936 in Santa Cruz County was 77,363, in Placer County 63,109; but 47 per cent of all anglers residing in Santa Cruz made reports, to only 27 per cent in Placer. Corrections can be and are made for this kind of distortion. Applied to the figures just given, they show that more trout were actually caught in Placer County than in Santa Cruz.

b. There is reason to believe that intensity of reporting varies among fishermen for different species. This is merely a reflection of the fact that this sample differs from most of those with which biological statisticians have to deal in that any individual unit has the ability to abstain voluntarily from participating in the count.

c. Many applicants, not having had licenses the previous year, are not eligible to turn in a catch record, and are obviously not properly represented by the reporting anglers. Allowances can be and are made for this.

d. Figures for licensees who caught no fish are very incomplete, because the great majority of such licensees, instead of writing "0" in the catch record, disregard it entirely.

The "reliability of the unit" is questionable because of doubt as to the accuracy of the angler's memory. His report is not made until a

year after the beginning of his previous season, which means that his chances of remembering correctly are diminished by lapse of time; and the report is made in the hurry and confusion of buying a new license.

No statistical measure of the "reliability of the unit" has been found, but ways do exist of making what might be called common-sense checks. Figures from counties of generally similar character show results of fairly close comparability; and figures for the same items in succeeding years can be compared, as for instance:

| | 1935 | 1936 | 1937 |
|---|---|---|---|
| Per cent of all reporting anglers who report trout | 58.2 | 59.6 | 57.6 |
| Average reported annual trout catch per man | 80.7 | 79.7 | 78.3 |

The close correspondence of these figures would indicate that individual errors to a large extent cancel out, and that considerable confidence can be placed in the results.

Another drawback in the present system is the time lag in the preparation of the finished report. The individual catch records for any fishing year are not all in the hands of the staff until all applications for the succeeding year have come in; and the time needed to sort and code them means that the tabulations are not ready for analysis until about the end of May of the second year after the close of the fishing year under consideration. For example, tabulations of the 1937 records were completed about the end of May, 1939. Analysis of the figures and compilation of the report require about another six weeks, but since the end of May is the time when active field work begins to demand all the time and attention of all men engaged in fisheries research, the final report is not apt to be ready before late in the following autumn.

## Improvements to the System

The system having been in operation only three years, improvements have been made as the need for them became apparent.

To test the whole question of the validity of the sample, a "Second Call" was operated in 1938. A random sample of the non-reporting fraction of the angling population was subjected to a questionnaire catch-record, sent by mail to every twentieth non-reporter. The results have not yet been completely analyzed, but there is no question but that they will be of value in forming an estimate of the unreported catch. They have already shed light on the question of "zero catches," indicating that 17.5 per cent of the non-reporting licensees made no catch in 1937—which would mean about 13 per cent of all licensees in 1937. Of those who made no catch, about one-half did not fish at all, while the other one-half fished unsuccessfully.

To test the reliability of the unit and at the same time to overcome the other drawbacks listed above, a plan is on trial for a mail sample of the whole angling population. This provides that catch-record

questionnaires be sent by mail to 10 per cent of all licensees, picked at random—a total of about 30,000 questionnaires. They will be sent immediately at the end of the calendar year so that they will reach the fisherman while his memory of his season's catch is still fairly fresh. They will permit him to make out his record in the quiet of his home or office, rather than in the confusion of the licensing agency. They will go only to licensees of the year. They will emphasize the fact that a "zero catch" should be recorded. The replies will all be in the hands of the staff by the end of winter, so that it should be possible to have the complete report ready by the following May—thus cutting down the lag between the end of the fishing year and the availability of the report for administrative purposes by about one and one-half years.

## Analysis of Results

For analysis, the results may be divided into two main categories: those that involve the anglers, and those that involve the fish caught.

The results that involve the anglers may be accepted as having a considerable degree of reliability. The total number of licensees resident in each county is recorded whether the applicant makes a catch-record return or not. The angler's record of the *kind* of fish he caught (trout, striped bass, sunfish, etc.) is subject to very little error. The record of the county in which he caught them, though more fallible, is nevertheless fairly close to the fact. We have, therefore, a whole series of records that deals with the distribution of the angling population by county of residence, by county of catch, and by species caught, which can be accepted with considerable confidence and which is of high value for administrative purposes, allocation of funds, etc.

Data that deal with numbers of fish caught are dependent upon the memory and the intent of the angler, and are necessarily of doubtful reliability. These data include the recorded totals of each species of fish caught in the state and in the different counties.

As examples of the above two categories it may be stated that the number of anglers who reported catching trout in the whole state is probably very close to the actual fact, whereas the total number of trout reported caught is of doubtful reliability. The number of anglers from Los Angeles who reported catching trout in Mono County is probably very close to the actual fact, whereas the number of trout reported caught by Los Angeles residents in Mono County is of doubtful reliability.

There exists still a third class of results: the estimates of what the non-reporting angling population caught, based on the records of those who did report. The principal item here is the estimate of how many trout the non-reporting anglers caught in the whole state, for this figure, added to the reported catch, gives an estimate of the total trout catch for the whole state.

The *estimated total* trout catch for 1937 is 11,900,000 fish. This does not include the catch of fishermen under 18 years of age, who are not

required to buy a license. Their catch is considerable, and might increase the total by 25 per cent.

It should be pointed out that this estimate is arrived at by applying corrections which were not available when the records were started. In the beginning, all that could be done was to assume that the same proportion of reporting and of non-reporting anglers fished for trout, and that the average catch per trout fisherman was the same among the non-reporting anglers as among the reporting. Applying this assumption gave the following results for the three years so far recorded:

| | 1935 | 1936 | 1937 |
|---|---|---|---|
| Estimated trout catch of non-reporting anglers | 9,600,000 | 10,600,000 | 10,000,000 |
| Actual reported catch of reporting anglers | 4,100,000 | 3,600,000 | 4,100,000 |
| Estimated total for all anglers | 13,700,000 | 14,200,000 | 14,100,000 |

The close approximation of these figures in order of magnitude gave some grounds for confidence in their reliability. However, they disregarded the licensees who caught no fish. The number of such licensees was quite unknown in 1935 and 1936, but the recently completed "Second Call" indicates that they constituted about 17.5 per cent of the 1937 *non-reporting* anglers. Applying this factor to the 1937 figures, we obtained:

1937 total trout estimate, first correction 12,300,000 fish.

The "Second Call" also indicated that only 53.6 per cent of the non-reporting anglers fished for trout in 1937, as against 57.6 per cent of the reporting; and that the non-reporting trout fishermen averaged 79.3 trout per man as against 78.3 for the reporters. Correcting again for these factors, we obtained the estimate already set forth:

1937 total trout estimate, final figure (twice corrected) 11,900,000 fish.

The 1935 and 1936 estimates could be corrected proportionally.

The question may be raised as to whether the "Second Call" percentage of non-reporting anglers who fish for trout, and their average trout catch, based on only about 2,000 records, is a truer representation of the non-reporting population than the figures obtained from the 90,000 original reporters. It is the opinion of the writer that the best estimate for the total 1937 trout catch would lie somewhere between the corrected 12,300,000 and the re-corrected 11,900,000—not counting the catch of the non-licensed fishermen under 18 years of age.

## Comparison with Mandatory Method

To the question why California does not pass a law making it mandatory for anglers to report their catches, there are two answers:

1. Compulsion is not a pleasant process either for the compeller or the compelled. It is felt that a better spirit of cooperation between the sportsmen and the Division of Fish and Game can be maintained

by securing a voluntary record willingly rendered than by making it mandatory on the willing and the unwilling alike.

2. A stronger reason is the belief that mandatory records may well be less accurate than voluntary ones. The possibility exists that a man who is hostile to the whole system, or merely indifferent, will, if faced with the necessity of making a report in order to obtain a license, put down the first figures that enter his head, regardless of what his catch actually was. Such an individual, under the voluntary system, will make no report at all. Those who do report may be considered to have enough interest in conservation to try to make their reports conform to the actual records of their catch.

The weakness of the *voluntary* system is its failure to secure reports from more than a fraction of the angling population—here, a three-year average of 27 per cent (from 75,000 to 90,000 records per year)—and the indifference of some of the licensing agents in securing anglers' catch records. As a sample, this percentage is amply large for all conceivable purposes. The unanswerable question is the extent to which the sample is a true representation of the non-reporting population.

The weakness of the *mandatory* system is the uncertainty as to the extent to which legal compulsion of unwilling reporters increases the unreliability of the individual records.

California at present prefers the former system to the latter.

# COMPARISON OF COHO SALMON FRY FROM EGGS INCUBATED IN GRAVEL AND IN HATCHERY BASKETS

G. Clifford Carl

*Pacific Biological Station, Nanaimo, British Columbia*

Abstract

**Eggs of Coho salmon (*Oncorhynchus kisutch*) were planted in gravel, and placed in open and in covered hatchery baskets in hatchery troughs to determine the possibility of the production of differences in eye diameter by incubation under the different conditions. No significant difference was found between any two of the three lots. In the gravel planting a number of eggs was unaccounted for, which fact may explain the high rates of efficiency obtained by basing estimates of losses in redds only upon the number of dead eggs remaining in the gravel.**

---

The Transactions of the American Fisheries Society for 1936 contained a paper by A. Robertson entitled "Hatching Fry in Gravel, No. 2," in which the author attempted to show that the method of incubating and hatching sockeye salmon (*Oncorhynchus nerka*) in gravel was superior to the usual hatchery practice. In support of his statement he outlined certain experiments performed at Harrison and at Cultus lake, British Columbia, in which eggs planted in gravel were alleged to have resulted in high returns. The greater efficiency of this method was said to be the result of the decided physical superiority of the fry hatched in gravel as compared with fish produced in hatcheries. The difference was claimed to be obvious in the larger eye and "capability of the oblique dart" of the former fish resulting from contact with "diatomaceous substances" present in the gravel in which they were incubated.

With regard to the efficiency of plantings in gravel as compared with hatchery incubation, reference may be made to the work of Foerster (1938) who has shown that there is no significant difference between the relative effectiveness of natural and artificial propagation of sockeye salmon at Cultus lake. The statement that fish reared artificially lose their sense of self preservation is refuted by observers such as Lord (1935) and Needham (1938). As to the possibility that morphological changes are produced by incubating eggs under hatchery conditions instead of in gravel, the present writer wishes to present data obtained from an experiment carried on during the winter of 1937-38 at the Cowichan Lake Hatchery, under the auspices of the Fisheries Research Board of Canada.

The experiment consisted of incubating and hatching eggs both in gravel and in the usual open hatchery basket to discover if any structural differences, particularly with reference to the size of the eye, were evident in the two lots of fry. The eggs selected were those of the Coho salmon since they were the most readily available. The ova,

taken from several ripe females by the dry-incision method, were intermingled thoroughly and fertilized in the usual manner. After the subsequent hardening process three lots of 2,000 eggs each were counted by hand. The first lot was placed in an open hatchery basket held in a hatchery trough; the second was placed in another basket covered so as to exclude light; and the third lot was planted in gravel in a separate trough screened at both ends. The eggs in the uncovered basket were exposed to the same light conditions as the majority of the eggs in the hatchery while those in the covered basket were in comparative darkness but otherwise were under identical conditions. The gravel used for the third lot was obtained from a portion of stream bed normally used as a spawning ground and was placed in the hatchery trough in such a way as to insure adequate circulation of water. The eggs were buried at a depth of 6 to 8 inches, and the entire experimental portion of the trough was covered to exclude light. The gravel was not disturbed until the fry had emerged after a period of twenty-two weeks, at which time the gravel was picked over carefully and a count was made of unhatched eggs and dead fry.

A sample of 100 free-swimming fry was taken from each lot and preserved in formalin. Measurements were then made of the total length and eye diameter. Calipers were used for the former measurement and a micrometer eyepiece for the latter. From these data the ratio of eye diameter to total length was calculated for each fish in each sample and the standard error of the average was determined. The average ratio of the eye diameter to the total length of fish from each lot was found to be as follows:

| | |
|---|---|
| Fry from open basket (control) | 0.0778 |
| Fry from gravel planting | 0.0777 |
| Fry from covered basket | 0.0770 |

The computation of standard errors of the averages revealed that no significant differences in the relative size of the eye existed between any two of the three groups of fish. The extremely close agreement between the ratios of eye diameter to total length of fry hatched in gravel and in the open basket is particularly significant in view of Robertson's (1936) statement that fry of sockeye salmon hatched in gravel had larger eyes than did hatchery fry.

The mortality experienced by each of the three lots of experimental eggs up to the time of hatching was high and differed considerably as follows: open basket, 12.1 per cent; covered basket, 17.6 per cent; gravel planting, 46.3 per cent. The high losses were probably the result of the extra handling during the intermingling of the eggs of different fish and during the subsequent counting. It may be noted at this point that although the gravel was picked over carefully by hand 160 eggs were not accounted for. A similar disintegration in nature may explain in part the high rates of efficiency obtained by basing the estimated loss in eggs in the redd only upon the number of "blank"

eggs found in the gravel. In this particular experiment a loss of 41.5 per cent instead of 46.3 per cent would have been reported had the calculation been based upon the number of fry produced as compared with the number of dead eggs recovered. Evidently it is sometimes impossible to account for all dead eggs or fry in gravel even under controlled conditions.

The writer is indebted to Dr. J. L. Hart of the Pacific Biological Station for advice and assistance in the statistical analyses.

## Literature Cited

Foerster, R. E.
1938. An investigation of the relative efficiencies of natural and artificial propagation of sockeye salmon (*Oncorhynchus nerka*) at Cultus lake, British Columbia. Journ. Fish. Res. Bd. Can., Vol. 4, pp. 151-161.

Lord, Russell F.
1935. "Hatchery trout go wild overnight." American Game, March-April, pp. 21 and 28, and May-June, pp. 38 and 47.

Needham, Paul R.
1938. Trout streams. Comstock Publishing Company, Inc. Ithaca, N. Y., 233 pp.

Robertson, Alexander
1936. Hatching fry in gravel, No. 2. Trans. Am. Fish. Soc. Vol. 66, pp. 279-282.

# AN EXPERIMENT IN HATCHING SILVER SALMON (*ONCORHYNCHUS KISUTCH*) EGGS IN GRAVEL

LEO SHAPOVALOV AND WILLIAM BERRIAN

*Bureau of Fish Conservation, California Division of Fish and Game*

## ABSTRACT

**The eggs from five adult sea-run silver salmon (*Oncorhynchus kisutch*) were divided into two lots: 8,239 eggs were buried in gravel in a standard hatchery trough and 7,500 placed in a standard hatching basket as a control. Natural conditions were simulated as closely as possible with the gravel eggs. The eggs required 772.3 temperature units (t.u.) to maximum hatch (control), 1,084.3 t.u. to earliest emergence from the gravel, and 1,155.6 t.u. to maximum emergence from the gravel. Initial to final emergence required at least thirty-eight days. Of the eggs buried, 10.2 per cent emerged from the gravel. In the control, 65.9 per cent of the eggs hatched and 48.2 per cent survived to the time that the experimental fish had finished emerging from the gravel. Examination of the gravel and the dead eggs in it at the conclusion of the experiment and observations made during previous experiments support the view that silt carried by unusually severe floods smothered many of the eggs in the gravel. This fact seems to account in large part for the small percentage of salmon emerging from the gravel. Fifty-six days after initial emergence from the gravel, the experimental fish averaged 23.8 fish per ounce (1.19 grams each, live weight) while the control lot averaged 27.6 fish per ounce (1.13 grams each). During these fifty-six days only forty-eight of the experimental fish died, whereas the mortality in the control lot for the same period totaled 905. In the final two weeks, however, the average daily mortality in the control was only one fish.**

---

In 1936 the writers conducted two experiments in hatching steelhead trout (*Salmo gairdnerii*)eggs in gravel (Shapovalov, 1937). The present experiment with silver salmon (*Oncorhynchus kisutch*) was designed with much the same purpose and carried out by the same methods employed in the steelhead trout experiments.

The purposes of the experiment were to determine, at least partially, the effectiveness of natural spawning of silver salmon, to discover what happens from the time the eggs are deposited in the gravel to their emergence from the gravel as fry, and to obtain other information that can be applied in an ultimate evaluation of artificial and natural propagation. It is hoped that a clearer picture of the processes involved in natural propagation will be had if we know such factors as the number of temperature units[1] required for eggs to hatch in the gravel, the number of temperature units required for hatched fry to work up to the surface of the gravel, the percentage of survival of the eggs spawned up to the time of emergence from the gravel, and the size and health of naturally hatched as compared with hatchery fish.

Both the present and previous experiments were conducted at the Big Creek State Fish Hatchery, 14 miles north of Santa Cruz, Cali-

---

[1]One temperature unit (t.u.) equals 1°F. above 32°F. for a period of twenty-four hours.

fornia, with eggs secured at the Scott Creek Egg Collecting Station, 1 mile away.

Between 11:00 and 11:30 a.m. on January 3, 1938, the eggs of five silver salmon were fertilized in the routine manner at the egg collecting station and then set aside in 2-quart glass jars. After the eggs were water-hardened they were taken to the hatchery. There 7,500 of the eggs (1,500 from each fish) were counted out and placed in a standard wire hatching basket suspended in flowing water in a standard hatchery trough. These eggs served as a control for the experimental lot of 8,239 eggs (the remaining available eggs from each fish), which were buried in gravel in the adjoining trough. Dead eggs were not picked out of either lot before counting.

Table 1 gives the data on the individual fish used in the experiment. The total egg production of the fish used in the experiment and the percentage of eggs obtained from them in stripping (99.6 per cent) agree closely with the data for the fish taken for the regular hatchery work at the same time. Ten fluid ounces of eggs taken from the control at 4 p.m. contained 809 eggs, or an average of 80.9 eggs per ounce.

TABLE 1. DATA ON INDIVIDUAL FISH USED IN THE EXPERIMENT

| Fish No. | Length in centimeters (tip of snout to fork of tail) | Total eggs produced | Left in fish in stripping | Total eggs obtained | Number in experimental lot | Number in control lot |
|---|---|---|---|---|---|---|
| 1 | 64 | 2,952 | 13 | 2,939 | 1,439 | 1,500 |
| 2 | 67 | 3,605 | 11 | 3,594 | 2,094 | 1,500 |
| 3 | 74 | 3,804 | 25 | 3,779 | 2,279 | 1,500 |
| 4 | 68 | 2,706 | 9 | 2,638 | 1,138 | 1,500 |
| 5 | 67 | 2,888 | 9 | 2,879 | 1,379 | 1,500 |
| Total | .... | 15,896 | 67 | 15,829 | 8,329 | 7,500 |
| Average | 68 | 3,179 | 13 | 3,166 | 1,666 | 1,500 |

The trough in which the experimental eggs were placed was first covered with gravel to a depth of 2 inches. The eggs were then scattered over the gravel and covered by an approximately uniform layer of 5 inches of gravel. The process of covering the eggs was begun at 3:30 p.m. and completed at 4:00 p.m. The water flowing over the gravel was approximately 1 inch in depth. Perforated plates were also placed before and behind the gravel in such a manner as to force some water to run through it. The gravel used had been rolled around in a piece of minnow seine under water in order to free it of most of the sand and silt that it contained. This gravel was taken from the creek bed just above the dam at the Scott Creek Egg Collecting Station and

was selected to simulate the type and size on which silver salmon ordinarily spawn.

We made no attempt to observe the eggs and fish in the gravel, as we had done in the first experiment with steelhead trout eggs. The eggs of the steelhead trout were placed in gravel in a glass aquarium screened at both ends. Since observations at that time showed that the eggs in the gravel hatched at approximately the same time as the control eggs, there is no reason to believe that a similar situation does not prevail with salmon eggs.

The eggs in the control lot hatched during a period of ten days, February 17-26, with February 20 the day of maximum hatch.

The day of initial emergence of fry from the gravel was March 9, when twenty-five fish appeared. The emerging fry were removed each day (usually several times a day) to a standard hatchery trough without gravel, so that an accurate check could be kept on the numbers emerging from the gravel. Maximum emergence occurred on the fourth day, when sixty-four fry appeared. However, the emergence was spread over a long period and numbers of fry nearly equal to the maximum emerged on the eighth, fifteenth, and twentieth days (sixty, sixty-two, and sixty-two fry, respectively). The total period of emergence covered at least thirty-eight days, March 9 to April 15. On May 4, six more fry were removed from the gravel trough, but it is possible that they had emerged between April 15 and May 4 and had escaped detection by hiding in crevices in the gravel. In the steelhead experiments the periods of emergence were also long: sixteen and twenty days. The long period of emergence may well account for some of the variation in size among naturally-spawned stream fish, even when all spawning occurs at approximately the same time.

The fish that emerged on the first day still had about one-half of their yolk sacs unabsorbed, whereas those emerging on the fourteenth day had absorbed their yolk sacs almost entirely.

It is quite interesting that apparently most of the fish emerged at night. Consistently more fish were removed from the gravel in the morning than in the afternoon. It is probable that a similar emergence in nature provides the young fish considerable protection from enemies.

Notes taken by Berrian on the morning of the first day of emergence are as follows: "They [the fish] have two holes formed in the gravel about 2 feet from the end of the trough and are emerging from these holes. I was watching one of the holes this morning and saw two come up. The holes were not there yesterday afternoon and were made during the night."

Table 2 shows the number of temperature units and the number of days that it took the eggs to reach various stages of development, and also the mean temperatures during the various periods. Table 3 shows the survival of the fish from the gravel and of those in the control.

**TABLE 2. NUMBER OF TEMPERATURE UNITS AND NUMBER OF DAYS REQUIRED FOR THE EGGS TO REACH VARIOUS STAGES OF DEVELOPMENT, AND THE MEAN TEMPERATURES PREVAILING DURING VARIOUS PERIODS**

**The eggs were fertilized on January 3, 1938**

| Period of development | Date | Temperature units | Mean temperature for period (°F.) | Number of days for period |
|---|---|---|---|---|
| To maximum hatch in control | February 20 | 772.3 | 48.0 | 48 |
| To first emergence from gravel | March 9 | 1,084.3 | 48.7 | 65 |
| Maximum hatch of control to first emergence from gravel | February 20-March 9 | 312.0 | 51.1 | 17 |
| To maximum emergence from gravel | March 12 | 1,155.6 | 48.9 | 68 |
| Maximum hatch of control to maximum emergence from gravel | February 20-March 12 | 383.3 | 51.2 | 20 |

It is seen that a total of only 850 fish or 10.2 per cent emerged from the gravel. In the two experiments with steelhead trout 29.8 per cent and 79.9 per cent of the fish emerged from the gravel. At that time it was stated by Shapovalov (1937) that he believed that natural (stream) conditions were simulated reasonably well. If this belief was correct it follows that in nature the percentage of deposited eggs which emerge from the gravel as fry may vary widely. It may be quite low under adverse conditions (silting, caused by flood, as in the first steelhead trout experiment, or mining pollution) and, on the other hand, it may be quite high under good conditions. In the present experiment some of the worst floods ever experienced occurred while the eggs were in the gravel (especially just after the eyed stage was reached), and the water in the hatchery troughs was laden with silt. On May 4, when the experiment was concluded, the gravel was removed by hand and a considerable amount of silt was found throughout it. A large number of eggs that had developed partially was found also. There is every reason to believe that they were smothered by the large quantities of silt that had settled around them. We believe that the present experiment provides an illustration of the fate met by naturally-spawned eggs under adverse conditions.

**TABLE 3. SURVIVAL OF FISH FROM THE GRAVEL AND OF THOSE IN THE CONTROL**

| Item | Gravel | Control |
|---|---|---|
| Original number of eggs | 8,239 | 7,500 |
| Number of eggs hatched | ....... | 4,943 |
| Eggs hatched as percentage of original number | ....... | 65.9 |
| Number of fish emerging from gravel and fish present in control at same time | 850 | 3,617 |
| Fish emerging from gravel and fish present in control at same time as percentages of original numbers of eggs | 10.2 | 48.2 |

Mortality during the period from initial emergence from the gravel to the conclusion of the experiment (fifty-six days) was 48 in the experimental fish (plus five injured in removal from the gravel) and

905 in the control lot. However, in the final two weeks the average daily mortality in the control was only one fish.

On May 4, 3,617 fish were counted in the control lot (131 ounces live weight) and 797 in the experimental lot (33.5 ounces). Thus, the fish in the control lot averaged 27.6 per ounce and those in the experimental lot 23.8 per ounce. The control and experimental lots were fed similar amounts and kinds of food, but the experimental fish, due to the long period of emergence, exhibited much greater variation in size than did the control fish.

## Literature Cited

Shapovalov, Leo
1937. Experiments in hatching steelhead eggs in gravel. Calif. Fish and Game, Vol. 23, No. 3, pp. 208-214.

---

## Discussion

Dr. Frederic F. Fish: Were all the eggs from the five fish placed in the same trough without partitions anywhere?

Mr. Shapovalov: Yes.

Dr. Fish: Do you suppose there was some inherent factor at work, in other words that the eggs from fish No. 5 might have taken longer to hatch? That long period of emergence seems strange.

Mr. Shapovalov: That would not explain the long period of emergence, because the fish in the control were from the same five fish. If we had taken the fish from a large river, we might have had different races, but that problem would hardly enter into a small stream such as Scott Creek.

The President: You have no information on the possible cause of the long period of emergence?

Mr. Shapovalov: No. The eggs were all buried at the same depth in this experiment, so that differences in depth should not account for it. There may be something in the way the gravel packs, especially when it is silted; there may have been pockets of silt and some fish may have worked a much longer time to escape from the gravel than others.

The President: There would be no differences in mortality as between the earlier ones and the later ones?

Mr. Shapovalov: In all the experiments the mortality is very low, once the fish have emerged from the gravel. Under natural conditions the fish that can fight their way out through the gravel will be in good condition. Babcock has cited the fact that too shallow burial is likely to result in the fish emerging with the yolk sac still attached. I think the fish that were slightly closer to the top emerged a little sooner than they should. Of course under natural conditions we hardly ever find any fish among the silver salmon that have remnants of the yolk sac still on after emerging.

Mr. Joseph H. Wales: I believe it is possible that some of these eggs in the gravel may have been situated in such a way that they received poor aeration, with a resulting slowing up in the rate of development. Other eggs in a better position would receive better aeration, their metabolism would be speeded up and they might hatch out a little earlier. Then, too, in a hatchery basket you will notice that when one fish hatches out of its shell it will agitate the surrounding eggs

and cause them to hatch out a little more rapidly than eggs in the same stage of development but not agitated by the surrounding eggs. Consequently if there were several eggs in the gravel near each other and if one of those eggs reached the point of development where it hatched out and agitated the surrounding eggs, those surrounding eggs would then hatch out more rapidly than others which were isolated from that precocious egg.

MR. SHAPOVALOV: I think that is a distinct possibility. The first emergence of the fish took place from the end of the standard trough. One might have thought that since the water was being forced in at the head of the trough these eggs would be better oxygenated and would hatch first, but the eggs toward the end of the trough still hatched first, despite the fact that they were 5 inches under the gravel. Your suggested explanation may account for this peculiarity in hatching.

DR. A. L. PRITCHARD: Did you make any attempt at the end of the experiment, after the emergence was over, to discover how many eggs actually were left in the gravel? Did you count every egg that was in there and make your totals check with the number you originally put in? I ask the question because some criticism was made of the work of Hobbs in New Zealand in that the dead eggs disintegrated very quickly. It has been held that the percentages that he obtained from digging up the redds are not really representative.

MR. SHAPOVALOV: We started to count the eggs in the gravel, but we could not get very far because there were eggs in all stages of decomposition. Some of the eggs were in fine condition when they were dug up, even two or three months from the time they were deposited, but other eggs were badly decomposed. We did remove all the gravel by hand, a rather laborious process which took several hours, but there were pieces of fish and pieces of eggs all through the gravel. It is very difficult to make an exact count.

DR. PRITCHARD: Dr. Greeley tried to make such a count, and there were approximately two hundred eggs he could not find. He assumed they had disintegrated.

THE PRESIDENT: I note that these fish were stripped. Was the usual process of removing eggs from trout employed?

MR. SHAPOVALOV: No, these fish were cut open. That is one reason why we got 99.4 per cent of the eggs contained in the fish. Of course, I do not mean that we had 99.4 per cent fertilization.

THE PRESIDENT: No particular attention was paid by the spawn-takers to removing the last egg?

MR. SHAPOVALOV: The number left in the fish varied from nine to a dozen. I would say that they were stripped fairly clean. Incidentally in examining silver salmon that have spawned naturally in these small coastal streams, we find they spawn almost all of their eggs. Fish that have finished spawning usually contain only a dozen or so eggs although sometimes as many as two dozen, or as few as two or three eggs are left in the fish. When we strip the fish—the steelhead for instance—without killing the fish, around 10 per cent of the eggs consistently are left in the fish.

MR. C. M. BLAKE: The chinook salmon of the later run have a habit of spawning on the same bed that the earlier ones used. I am wondering what effect that has on the eggs that are already deposited in the gravel. The fish that spawn later may cover the eggs of early spawners considerably deeper than was intended.

MR. SHAPOVALOV: I think there is every reason to believe that in some streams later runs of the same species of fish or of other species—trout, salmon, or others—may destroy many of the naturally-spawned eggs and also expose them to predators.

# COPPER SULPHATE AND ROTENONE AS FISH POISONS[1]

M. W. Smith

*Atlantic Biological Station, St. Andrews, New Brunswick.*

## Abstract

**A concentration of 3 p.p.m. of copper sulphate was effective in killing fish in the acid waters of four Nova Scotian lakes. The plankton and the bottom fauna were almost entirely destroyed. Rooted aquatic vegetation was largely unaffected. About a year elapsed before plankton and aquatic insects returned in quantity. Mollusks have not repopulated the lakes. Considerable copper remained in the waters for some time, but there was evidence that much was in a combined, non-toxic form.**

**At 5° and 20°C., concentrations of derris and cubé (5 per cent rotenone) as low as 0.20 p.p.m. killed yearling trout. At 10°C., 0.20 p.p.m. of derris (3 per cent rotenone) was toxic to suckers and lake chubs. In a small lake, 0.25 p.p.m. of derris (5 per cent rotenone) killed eels, lake chubs, sticklebacks, black bass and white perch, but a few eels, lake chubs and sticklebacks survived. Storing derris and cubé powders in a dry condition as long as three years did not affect their toxicity to brook trout. Increased temperature speeded greatly the action of rotenone (derris and cubé powders). Brook trout that had lost their equilibrium in water treated with rotenone revived in untreated water. Planktonic crustaceans were largely destroyed by concentrations of rotenone sufficient to kill fish in natural waters, but aquatic insects, mature and immature, mollusks, Hydracarina, certain rotifers, algae and rooted aquatics were not destroyed. In a small lake in which the original concentration of derris (5 per cent rotenone) was 1.33 p.p.m. the water remained toxic to fish for approximately one month.**

## Introduction

In recent years both copper sulphate and rotenone (derris powder) have been used to destroy undesirable fish. Under the Fish Culture Branch of the Canadian Department of Fisheries four lakes in Nova Scotia have been treated with copper sulphate (Catt, 1934; Smith, 1935, 1938). After the destruction of predators and competitors of trout in these lakes, stocking with trout fingerlings may prove more successful than in the past. In Michigan, Eschmeyer (1937, 1938) has employed rotenone, as contained in derris powder, to destroy populations of stunted perch. Derris powder was used also to kill the fish population of a stream from which a newly established hatchery secures its water supply (M'Gonigle and Smith, 1938). The poisoning in this stream was done as a "public health" measure, to avoid possible infection of the hatchery stock by water-borne diseases from native fish, particularly trout and salmon.

The destruction of entire fish populations provides the opportunity to secure valuable information upon the standing crop of fish in various types of waters. It may prove feasible to utilize poisons as a direct means of studying the production of fish in streams and lakes.

[1]Published with the permission of the Fisheries Research Board of Canada.

On the other hand, caution must be exercised, for indiscriminate poisoning may cause irreparable damage.

### Toxicity of Copper Sulphate

*Fish*—The dose of copper sulphate required to kill fish depends, among other factors, upon the species, the temperature and degree of hardness of the water, and the content of organic matter—dissolved and particulate. Smith (1924), who reviewed tests by various investigators upon the toxicity of copper sulphate to several species of fish, found considerable variation, even when only one species was concerned. This variation is probably due to diverse water conditions.

Temperature has a considerable effect upon the toxicity of copper sulphate to plants and animals (Powers, 1917). Moore and Kellerman (1904) recommended that an effective dose for algae at 15°C. be increased or decreased 2.5 per cent for each degree below or above this temperature. In the treatments that we have made, the copper sulphate was added to the waters in late July or early August in order to take advantage of the highest water temperatures. In a lake with stratified waters, the temperatures in the hypolimnion may be quite low, and the dosage should be increased accordingly.

Carpenter (1927) showed, that for lead poisoning, the metallic ion precipitates the mucus upon the gills of the fish, and that death from suffocation results. The action of copper, another heavy metal, is probably similar. Thus it is the concentration of the copper ion that is important in the treatment of waters for the destruction of fish, rather than the presence of copper in combined form, inorganic or organic. Topley and Wilson (1936) stated that the toxicity of the salts of the heavy metals to bacteria is in proportion to the concentration of free metallic ions and of free hydrogen ions. On the other hand, Powers (1917) suggested that the heavy metals owe their toxicity to their ability to form colloidal solutions, which are very toxic. In hard waters, copper sulphate reacts with the bicarbonates to form a basic copper carbonate, and ultimately the insoluble copper hydroxide (Ellms, 1905). Accordingly a greater dosage is required in hard than in soft waters. Moore and Kellerman (1905) recommended that the dose be increased by 0.5 per cent for each 10 p.p.m. of bicarbonate, and also increased 2 per cent for each 10 p.p.m. of organic matter, since copper is removed from solution by various organic materials (Carroll, 1904; Smith, 1905). In fact, copper, due to its affinity for organic matter, has been used as an index of the amount of organic detritus in water (Riley, 1937).

Since so many factors combine to determine the lethal concentration of copper, it is advisable that tests be made with the species one wishes to destroy and in samples of the water to be treated. Prior to the treatment of Lake Jesse, Nova Scotia, Catt (1934) made tests upon indigenous fish in water from this lake. (The determined

pH range and bicarbonate content of Lake Jesse waters varied from 6.2 to 6.6 and 9.5 to 11.3 p.p.m. respectively.) It was found that 1 p.p.m. of $CuSO_4 \cdot 5H_2O$ was approximately the minimum concentration required to kill white perch (*Morone americana*) and yellow perch (*Perca flavescens*). The general result indicated that 3 p.p.m. would kill all fish. The treatment of Lakes Jesse, Boar's Back, Tedford, and Trefry's with this concentration has proved effective, although in Lake Jesse some eels (*Anguilla rostrata*) and killifish (*Fundulus diaphanus*) survived (Catt, 1934; Smith, 1935). A certain number of killifish survived in Tedford Lake also. The observed pH range of the waters in the above lakes, excluding Jesse, were: Tedford, 5.6 to 6.4; Boar's Back, 4.3 to 4.6; Trefry's, 5.7 to 6.3.

*Aquatic invertebrates*—The concentration of 3 p.p.m. of copper sulphate destroyed most of the plankton and bottom fauna of the Nova Scotian lakes, although some forms were more resistant than others. Cladocerans were very susceptible, while certain copepods, such as *Mesocyclops obsoletus,* were present in reduced numbers for some days following the treatment, but ultimately disappeared from net-plankton samples. Likewise, Hydracarina, particularly nymphs, proved fairly resistant in Lake Jesse. Moore (1923) observed that a few leeches, notably *Macrobdella decora,* were able to survive treatment with copper. See also Ellis (1937) for certain tests on invertebrate forms.

Comparative counts of planktonic Crustacea, made from comparable fifteen-minute tows with a No. 5 plankton net, are presented in Table 1. Each sample was diluted to 450 milliliters, and the Crustacea in ten 1-milliliter samples were counted. Thus the data in Table 1 represent the numbers of any particular species in an average milliliter of the diluted samples. Plankton samples were taken before and some time after the addition of the copper sulphate. Although the plankters were largely destroyed, the later repopulation of the lakes shows that a small number of the several forms may have escaped the toxic action of the copper. Since the lakes are headwaters, the repopulation occurred presumably from survivors in the lakes themselves rather than from a restocking from waters above. The restocking appears too thorough to have been made by chance by birds or other agencies. About a year elapsed before the planktonic Crustacea became numerous in the net hauls.

The bottom fauna appeared to be as nearly destroyed as the plankton. If the bottom fauna were destroyed completely it is possible that aquatic insects could replenish the lakes through the migration of adults from adjacent waters, but the molluscan population would require a much longer interval of time to become reestablished. Samples of the bottom fauna indicate that the insect fauna returned fairly rapidly. However, the mollusks did not reestablish themselves. As with the plankton, a small representation of the bottom fauna, in-

TABLE 1. COMPARATIVE COUNTS OF PLANKTONIC CRUSTACEA IN NOVA SCOTIAN LAKES
(The plus signs indicate counts less than one. In each lake all collections except that of the earliest date were made after treatment with copper sulphate.)

| Date of collection | Plankton Organism | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Sida* | *Latona* | *Diaphanosoma* | *Holopedium* | *Daphnia* | *Ceriodaphnia* | *Bosmina* | *Ophryoxus* | *Drepanothrix* | *Acantholeberis* | *Chydorus* | *Polyphemus* | *Leptodora* | *Epischura* | *Diaptomus* | *Cyclops* | **Totals** |
| | | | | | | | **Lake Jesse** | | | | | | | | | | |
| Aug. 1, 1934 | .... | .... | 115 | 47 | 19 | .... | 10 | .... | .... | .... | .... | 1 | 1 | 2 | 67 | 54 | 316 |
| Aug. 4, 1934 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 14 | 20 | 34 |
| Aug. 7, 1934 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 15 | 15 |
| May 10, 1935 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 8 | 11 | 19 |
| Oct. 31, 1935 | 1 | .... | 1 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 786 | .... | 788 |
| May 9, 1936 | 3 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 456 | .... | 459 |
| Aug. 8, 1936 | .... | 12 | 5 | 4 | 1 | .... | 2 | .... | .... | .... | .... | .... | 1 | 3 | 665 | .... | 693 |
| Nov. 5, 1936 | .... | .... | 2 | 24 | 5 | .... | 433 | .... | .... | .... | .... | .... | .... | 14 | 203 | .... | 681 |
| May 5, 1937 | .... | .... | 16 | 36 | 130 | .... | 1,866 | .... | .... | .... | .... | 10 | .... | .... | 236 | .... | 2,294 |
| | | | | | | | **Boar's Back Lake** | | | | | | | | | | |
| July 14, 1936 | .... | .... | 538 | 88 | .... | .... | 14 | .... | .... | .... | .... | + | .... | .... | 518 | 69 | 1,227 |
| Aug. 7, 1936 | .... | .... | .... | .... | .... | .... | .... | .... | + | .... | .... | .... | .... | .... | 6 | 5 | 11 |
| Nov. 4, 1936 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| May 4, 1937 | .... | .... | .... | 3 | .... | .... | 3 | .... | .... | + | + | .... | .... | .... | 177 | 6 | 189 |
| Sept. 23, 1937 | .... | .... | 7 | 25 | .... | .... | 300 | .... | .... | .... | .... | .... | .... | .... | 150 | 874 | 1,356 |
| May 5, 1938 | .... | .... | + | 20 | 1 | .... | 120 | + | .... | .... | .... | .... | .... | .... | 268 | 108 | 517 |
| Aug. 10, 1938 | .... | .... | 662 | 91 | + | .... | 92 | .... | .... | .... | .... | + | .... | .... | 114 | 254 | 1,213 |
| | | | | | | | **Tedford Lake** | | | | | | | | | | |
| July 28, 1936 | .... | .... | 348 | 17 | 6 | 46 | 23 | 1 | .... | .... | .... | .... | .... | 2 | 238 | 94 | 774 |
| Aug. 4, 1936 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 3 | 27 | 30 |
| Nov. 5, 1937 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| May 5, 1937 | .... | .... | 1 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 4 | 192 | + | 197 |
| Sept. 23, 1937 | .... | .... | 63 | + | 12 | .... | 30 | .... | .... | .... | .... | .... | .... | 3 | 164 | .... | 272 |
| May 6, 1938 | .... | .... | 207 | 5 | 7 | .... | 150 | .... | .... | .... | .... | .... | .... | .... | 116 | 7 | 492 |
| Aug. 10, 1938 | .... | .... | 6 | .... | 141 | .... | + | .... | .... | .... | .... | .... | .... | 17 | 300 | .... | 464 |

cluding mollusks, might be expected to escape. The more rapid return of insects might indicate the restocking from other waters.

Tedford Lake was treated with copper sulphate on July 31, 1936. Samples from this lake, obtained by dredging, on May 6, 1938, showed that among the reeds there was an estimated population of 249 chironomid larvae, 77 caddis fly nymphs, 58 leeches and 19 aquatic earthworms per square metre. At a depth of 3 metres in the open water there was a population of 19 chironomid larvae, 19 *Corethra* larvae and 19 damselfly nymphs per square metre. Aquatic hemipterans and coleopterans were also present. In Lake Jesse and Boar's Back Lake also, the insect fauna returned.

*Higher aquatic vegetation*—In the Nova Scotian lakes higher aquatics such as those of the genera *Nymphaea, Juncus, Pontederia, Scirpus, Eriocaulon,* and *Potamogeton* were not affected by copper-sulphate concentrations of 3 p.p.m. In Tedford Lake, it was noted that the edges of some leaves of *Castalia odorata* were "burnt," but it was the only form that manifested any apparent damage. Sufficient copper may have remained in the bottom mud to affect the roots of higher aquatics over an extended period, particularly if the copper was in an ionic form, but any damage of this character would be difficult to assess.

Caird (1905) found that potamogetons were destroyed in a reservoir treated with 0.3 p.p.m. of copper sulphate, but Moore and Kellerman (1905) reported no damage to water lilies and cattails from 0.1 p.p.m.

*Algae*—Algae are killed by low concentrations of copper sulphate, the actual toxicity of the salt depending upon the species and the water conditions. Smith (1924) has compiled a table of data of several investigators upon the toxicity of copper sulphate to many algae. Copper sulphate has been used commonly to destroy obnoxious algae in water reservoirs, particularly before the advent of the more modern filtration systems, and also to eliminate "water-blooms" in lakes and ponds, either natural or artificial, employed for recreational purposes.

Three p.p.m. of copper sulphate in the Nova Scotian lakes destroyed the algal populations almost entirely. Fifteen-minute tows with a No. 18 plankton net secured very few algae for a year or so after the treatment. (Lake Jesse was treated on August 3, 1934, Tedford Lake on July 31, 1936, and Boar's Back Lake on August 5, 1936.) Before the treatment of Lake Jesse the phytoplankton was dominated qualitatively by desmids (Smith, 1938). Tows in 1935, 1936 and 1937 showed no return of these forms. A tow on May 9, 1936, collected an abundance of *Synura* and took *Tabellaria* in a lesser quantity. Tows on August 8, 1936, and May 5, 1937, took little phytoplankton, while another tow on September 23, 1937, caught considerable *Dinobryon*. In Tedford Lake, diatoms of the genus *Tabellaria* were found to be the most common forms in 1937, although they were

still quantitatively poor. On May 6, 1938, an abundance of *Synura*, with smaller numbers of *Mallomonas, Dinobryon*, and *Tabellaria*, was found. Before the treatment of Boar's Back Lake, dinoflagellates were abundant. These algae had not returned to the phytoplankton by August 10, 1938, but diatoms, particularly *Asterionella* and *Tabellaria* were common in 1937, and increased in abundance in 1938. A few desmids (*Staurastrum, Xanthidium, Micrasterias, Euastrum*) were also taken in the hauls during 1938.

## The Disappearance of Copper from Lakes

In lakes with outlets, such as we have treated, the copper that remains in solution, or in suspension in combination with organic matter, gradually disappears as a result of the natural run-off. The rapidity with which the copper compounds disappear in this fashion will naturally depend upon the season and the drainage. If the outflow is considerable while the treatment is being made, sufficient copper may flow into waters below to cause damage. This damage can be avoided, or reduced to a minimum, by treating when the waters are low and by damming the outlet to prevent immediate drainage.

In hard waters the ionic copper is precipitated from solution quickly by bicarbonates. Considerable precipitated copper may accumulate in the bottom muds. In very alkaline waters, effective treatment with copper sulphate is difficult, even when high concentrations are used. In acid waters, as in the Nova Scotian lakes, comparatively little copper is removed from solution by the bicarbonates; the greatest reduction is due to the combination of the copper with various forms of organic matter.

In Table 2 are shown analyses of the copper content in the waters of Lakes Jesse, Tedford, and Boar's Back. These data demonstrate that considerable copper remained (suspended, colloidal, or soluble) in the acid waters of these lakes for some time, and that copper had accumulated to some degree in the bottom muds. (Some of the data for Lake Jesse have been recorded previously by Smith, 1935).

The copper content of the water may be determined colorimetrically by the use of sodium diethyldithiocarbamate (Callan and Henderson, 1929; Moseley, Rohmer and Moore, 1934). This reagent which is sensitive to 0.01 p.p.m. of copper, was used in the analysis of the copper content of Tedford and Boar's Back waters, and for the Lake Jesse samples of June 9 and July 10, 1935, and May 9 and November 5, 1936. The other determinations for Lake Jesse were made through the courtesy of Dr. G. S. Whiby at the National Research Laboratories by the ferrocyanide colorimetric method.

In the carbamate method of analyses, the samples were first digested with *aqua regia* to destroy the natural colouring substances that interfere with the reading. Thus it was impossible to ascertain in what combination the copper existed in the samples. There is evidence, shown by the growth of certain algae in stored samples and in the

**TABLE 2. COPPER ANALYSES OF NOVA SCOTIAN LAKE WATERS**

| Date | Location | Copper as p.p.m. of $CuSO_4 \cdot 5H_2O$ | Remarks |
|---|---|---|---|
| | **Lake Jesse** | | |
| Aug. 3, 1934 | Initial dose | 3.06 | Calculated |
| | Surface | 1.10 | |
| | 5.5 metres (bottom) | 0.94 | Clear |
| | Mixed samples from several points in the lake | 0.90 | |
| Aug. 4, 1934 | Surface | 1.06 | |
| | 5.5 metres (bottom) | 0.90 | Clear |
| | Surface at west shore | 1.06 | |
| Aug. 8, 1934 | Surface | 0.94 | |
| | 5.5 metres (bottom) | 0.98 | Clear |
| Aug. 10, 1934 | Surface | 0.90 | |
| Aug. 24, 1934 | Surface | 2.28 | |
| Sept. 15, 1934 | Surface | 2.44 | |
| Oct. 3, 1934 | Surface | 1.77 | |
| | 5 metres (bottom) | 2.13 | Clear |
| Dec. 6, 1934 | Surface | 1.20 | |
| Mar. 20, 1935 | Surface | 0.47 | |
| May 10, 1935 | Surface | Trace (0.02) | |
| | 4.5 metres (bottom) | 2.03 | Clear |
| June 9, 1935 | Surface | 0.24 | |
| | 5.5 metres (bottom) | 0.90 | Approximately 2 per cent mud |
| July 10, 1935 | Surface | 0.24 | |
| May 9, 1936 | 5.5 metres (bottom) | 0.90 | Clear |
| | 5.5 metres (bottom) | 2.67 | Approximately 10 per cent mud |
| Nov. 5, 1932 | 5.5 metres (bottom) | 0.31 | Almost clear |
| | **Tedford Lake** | | |
| July 31, 1936 | Initial dose | 3.16 | Calculated |
| | Surface | 3.03 | |
| | 2 metres | 2.75 | |
| | 3.7 metres (bottom) | 3.38 | Clear |
| Aug. 2, 1936 | Surface | 2.67 | |
| Aug. 5, 1936 | Surface | 1.89 | |
| | 2 metres | 2.28 | |
| | 3.5 metres (bottom) | 3.65 | Considerable mud |
| Nov. 5, 1936 | Surface | 0.86 | |
| | 4.25 metres (bottom) | 0.86 | Clear |
| | 4.25 metres (bottom) | 3.22 | Considerable mud |
| | Bottom (among *Juncus*) | 3.77 | Considerable mud |
| May 5, 1937 | Surface | 0.20 | |
| | 3 metres | 0.24 | |
| | 4.75 metres (bottom) | 0.31 | Clear |
| | Bottom (among *Juncus*) | 0.43 | Little mud |
| Sept. 24, 1937 | Surface | 0.24 | |
| | 3 metres | 0.35[1] | |
| | 4.5 metres (bottom) | 0.24 | Clear |
| | **Boar's Back Lake** | | |
| Aug. 5, 1936 | Initial dose | 3.03 | Calculated |
| Aug. 6, 1936 | Surface (Station 1) | 2.44 | |
| | 2.5 metres (Station 1) | 3.36 | |
| | 5 metres (bottom, Station 1) | 1.53 | Little mud |
| Aug. 7, 1936 | Surface (Station 2) | 2.40 | |
| | 4 metres (Station 2) | 2.28 | |
| | 8 metres (bottom, Station 2) | 1.26 | Considerable mud |
| Aug. 10, 1936 | Surface (Station 1) | 3.22 | |
| | 4.5 metres (bottom, Station 1) | 3.06 | Little mud |
| | Surface (Station 2) | 2.16 | |
| | 4 metres (Station 2) | 1.89 | |
| | 7.5 metres (Station 2) | 1.49 | Clear |
| | 8 metres (bottom, Station 2) | 1.38 | Considerable mud |
| Nov. 4, 1936 | Surface at east shore | 0.83 | |
| | 5.5 metres (Station 1) | 1.02 | Clear |
| | 5.75 metres (bottom, Station 1) | 1.10 | Little mud |
| | Surface (Station 2) | 0.98 | |
| | 4 metres (Station 2) | 1.14 | |
| | 8 metres (bottom, Station 2) | 1.06 | Clear |
| | 8 metres (bottom, Station 2) | 1.22 | Little mud |
| May 4, 1937 | 4.5 metres (bottom, Station 1) | 0.31 | Little mud |
| | Surface (Station 2) | 0.22 | |
| | 4 metres (Station 2) | 0.26 | |
| | 8 metres (bottom, Station 2) | 0.31 | Little mud |
| Sept. 23, 1937 | Surface (Station 2) | 0.16 | |
| | 5 metres (Station 2) | 0.37 | |
| | 8.75 metres (Station 2) | 0.47 | Clear |

[1]The digest from this sample had a slight yellow colour which could not be dispelled; consequently the value is too high.

lakes themselves, that after some days the copper was not in a simple ionic form but was in a non-toxic combination, for analysis demonstrated that the samples contained an amount of copper that would have been toxic as copper sulphate.

### Method of Application of Copper Sulphate

The towing of the copper sulphate, contained in gunny sacks, from outriggers fastened to row boats seems to provide the best method of application. This method was used by Moore and Kellerman (1904), Smith (1924) and Catt (1934). In Trefry's Lake, which has stratified waters, a quantity of copper sulphate, proportional to the volume of water, was distributed below the thermocline by weighting the bags.

In Trefry's Lake, 6,000 pounds of copper sulphate were distributed easily in the above manner in ten hours by five boats and ten men. A hand spray pump might be used advantageously in shallow water and other areas inaccessible to boats.

### Toxicity of Rotenone (Derris and Cubé Powders)

***Fish***—Rotenone, as contained in derris and cubé roots, is toxic to fish in very low concentrations. This substance, with other less toxic constituents, occurs chiefly in the roots of a number of tropical legumes. Commercial derris is secured from *Deguelia elliptica* (East Indies) and cubé from *Lonchocarpus nicou* (South America). Although derris and cubé roots contain varying amounts of rotenone, commercial products are standardized at a certain rotenone content. The chief use for derris and cubé is as insecticides.

In the following pages all results are expressed as so many parts of derris (or cubé) per million (p.p.m.). Unless otherwise specified, the concentrations are in terms of derris or cubé with a rotenone content of 5 per cent.

In tropical districts where the plants containing rotenone are indigenous, the natives have long used them to capture fish, but only recently has rotenone been used in fish-management practice for the destruction of undesirable fish. In Michigan, Eschmeyer (1937, 1938) used derris root powder (5 per cent) to kill fish in three small lakes. Dynamite was used in addition in two of the lakes to insure mixing. In South Twin Lake (4.3 acres; 12.7 metres maximum depth) about 48 pounds of derris destroyed almost the entire yellow perch population. In Ford Lake (11.7 acres; 10 metres maximum depth; stratified) 200 pounds of derris killed a population of yellow perch, trout and minnows. In a third lake, Section Four (3.3 acres; 21.7 metres maximum depth; stratified), about 75 pounds of derris appeared to kill all yellow perch.

Brook trout (*Salvelinus fontinalis*) were all killed in McCormick Lake, Nova Scotia, by a treatment of derris in an estimated concentration of 1.33 p.p.m. (M'Gonigle and Smith, 1938). McCormick Lake has an area of 6 acres and a maximum depth of 3 metres. Sec-

ond River, to which McCormick Lake is tributary, was also treated with the same grade of derris. Almost all trout and salmon parr in the stream were killed. As an additional test of the action of rotenone in nature, Bill's Lake, New Brunswick, was treated on June 16, 1938, with 0.25 p.p.m. of derris powder, and later, after the effects of the first treatment had disappeared, was treated again on September 8, 1938, with an increased concentration of 1 p.p.m. of derris of the same rotenone content. Bill's Lake has an area of 10.5 acres and a maximum depth of 3 metres. The pH value ranged from 6.2 to 6.8. On June 13, 1938, the temperature of the water was 20.5°C. at the surface and 13.7°C. at the bottom, and on September 7, 1938, these temperatures were 15.6 and 13.7°C., respectively.

The weaker concentration employed in June killed eels, lake chubs (*Couesius plumbeus*), sticklebacks (*Pungitius pungitius*), white perch and smallmouth black bass (*Micropterus dolomieu*), the last two having been introduced into the lake just prior to the treatment. The dose of 1 p.p.m. of derris in September showed that some eels, chubs, and sticklebacks had survived the treatment with 0.25 p.p.m. In June, 2,042 eels were counted from the lake, and in September, 204; 656 chubs were counted in June, and 5 in September.

In a number of controlled tests, Leonard (1939) found that the common shiner, golden shiner, bluegill, common sunfish, brook stickleback, mud minnow, and goldfish were killed with 0.50 p.p.m. of derris (5 per cent) at 60°F., but that 0.25 p.p.m. of derris did not kill the common shiner and bluegill. The mud minnow and goldfish were the most resistant of the species tested. It is noteworthy that goldfish died more rapidly in acid than in alkaline water.

The toxicity of derris (3 per cent) to the common sucker (*Catostomus commersonnii*), lake chub, white perch and killifish was tested by the author at several concentrations. The fish were held in 20 gallons of water (pH, *ca.* 7.0) in wooden tubs, and were introduced before the derris, from fresh stock suspension, was added. Controls were maintained without mortalities.

The results are given in Table 3. The sucker and chub experiments ran overnight, and, as a result, irregular observations permitted only records that the fish died in less than a certain time. A concentration of 0.20 p.p.m killed fish, but apparently is a "borderline" concentration since two suckers survived at approximately 10°C. Concentrations of 1.00 and 0.50 p.p.m. were quite effective.

Several samples of derris and cubé powders were tested on yearling brook trout (*Salvelinus fontinalis*) by Messrs. A. P. Hills and F. A. Tingley, District Supervisors of Fish Culture, under the direction of Dr. R. H. M'Gonigle, Fish Pathologist at the Atlantic Biological Station. The author thanks these investigators for the opportunity of recording here a summary of their results (Table 4). At 20°C. two experiments were conducted with sample No. 1 and three experiments with sample No. 3. The gaps in the table signify no experiment.

**TABLE 3. TOXICITY OF DERRIS (3 PER CENT ROTENONE) TO FISH**

| Concentration of derris; p.p.m. | First dead (minutes) | Last dead (minutes) | Average time for death (minutes) |
|---|---|---|---|
| **Common sucker** *(Catostomus commersonnii)*; **22.4 to 29.9 centimeters long. (Four fish in each concentration; temperature 8.6° to 10.05°C.)** | | | |
| 1.00 | 257 | 393 | 349 |
| 0.50 | 272 | 725 | 389 |
| 0.40 | 405 | less than 1,382 (no survivors) | ...... |
| 0.20 | 724 | less than 1,383 (two survivors) | ...... |
| **Lake chub** *(Couesius plumbeus)* **(Four fish in each concentration; temperature 7.5° to 12.0°C.)** | | | |
| 1.00 | 235 | 303 | 275 |
| 0.50 | ...... | less than 551 | ...... |
| 0.33 | ...... | less than 549 | ...... |
| 0.25 | less than 549 | less than 1,333 | ...... |
| 0.20 | less than 545 | less than 1,329 | ...... |
| **White perch** *(Morone americana)* **(Two fish in each concentration; temperature, 18.2° to 20.6°C.** | | | |
| 2.00 | 54 | 56 | 55 |
| 1.00 | 81 | 84 | 83 |
| 0.50 | 127 | 131 | 129 |
| 0.33 | 163 | 171 | 167 |
| 0.25 | 211 | 218 | 215 |
| **Killifish** *(Fundulus diaphanus)* **(Ten fish; temperature 18.9° to 23.0°C.)** | | | |
| 1.00 | 95 | 152 | 121 |

**TABLE 4. TOXICITY OF DERRIS AND CUBÉ TO YEARLING TROUT**

**The concentration of rotenone was 3 per cent in samples 4 and 5, and 5 per cent in the remaining samples**

| Sample | Time of death in minutes at concentrations in p.p.m. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.20 | 0.25 | 0.33 | 0.50 | 1.00 | 2.00 | 3.00 | 5.50 | 11.00 |
| **Temperature, 5°C.** | | | | | | | | | |
| 1. Derris | 308 | 307 | 206 | 193 | 165 | ...... | ...... | ...... | ...... |
| 2. Derris | ...... | ...... | ...... | 251 | 237 | 137 | 85 | ...... | ...... |
| 3. Derris | 520 | 1,430 | ...... | 330 | 312 | ...... | ...... | ...... | ...... |
| 4. Derris[1] | ...... | ...... | ...... | 330 | 200 | 165 | 125 | ...... | ...... |
| 5. Derris[1] | 500 | ...... | ...... | 480 | 277 | 168 | 125 | ...... | ...... |
| 6. Cubé | 602 | ...... | ...... | 581 | 270 | 157 | 87 | ...... | ...... |
| 7. Cubé | 468 | 370 | 355 | 285 | 155 | ...... | ...... | ...... | ...... |
| **Temperature, 20°C.** | | | | | | | | | |
| 1. Derris | 60 | 45 | 50 | 40 | 30 | ...... | ...... | ...... | ...... |
| 1. Derris | 70 | 60 | 56 | 50 | 36 | ...... | ...... | ...... | ...... |
| 2. Derris | 79 | ...... | ...... | 54 | 34 | 34 | 23 | ...... | ...... |
| 3. Derris | ...... | ...... | ...... | ...... | 33 | 35 | 25 | 28 | 24 |
| 3. Derris | 57 | 46 | 107 | 57 | 52 | ...... | ...... | ...... | ...... |
| 3. Derris | 40 | 155 | 50 | 40 | 28 | ...... | ...... | ...... | ...... |
| 4. Derris[1] | 325 | ...... | ...... | 77 | 54 | 41 | 38 | ...... | ...... |
| 5. Derris[1] | 60 | ...... | ...... | 35 | 35 | 22 | 25 | ...... | ...... |
| 6. Cubé | 77 | ...... | ...... | 54 | 32 | 24 | 23 | ...... | ...... |
| 7. Cubé | 62 | 60 | 59 | 32 | 29 | ...... | ...... | ...... | ...... |

[1]The derris (3 per cent) was used in the experiments with Samples 4 and 5 in greater quantity than shown in p.p.m. Equivalent amounts were taken to produce as great a concentration of rotenone as that produced by derris with a rotenone content of 5 per cent.

These tests are important as showing the effect of storage on the samples, and the effect of temperature on the toxicity.

The samples of derris and cubé powders, indicated in the table, had the following histories since purchased by us. The tests were made in November, 1938.

1. Derris powder obtained from Derris, Inc., New York. Received in November, 1938, and used within a few days.
2. Derris powder obtained from Derris, Inc., New York. Received in August, 1937, and retained in glass jars in diffuse light.
3. Same as number 2, but held at the Cobequid Fish Hatchery, Nova Scotia, in paper bags, and shipped to us in November, 1938.
4. Derris powder (3 per cent), obtained from the National Drug Co., St. John. Received in August, 1935, and retained in a paper bag in the dark.
5. Derris powder (3 per cent), obtained from the National Drug Co., St. John. Received in the spring of 1937 and retained in glass jars in diffuse light. This sample was that used for the tests reported in Table 3.
6. Cubé powder, obtained from Derris, Inc., New York. Received in the fall of 1937 and retained in a paper bag in the dark.
7. Cubé powder, obtained from Derris, Inc., New York. Received in November, 1938, and used within a few days.

As only a single fish was used for each test the results were rather variable. However, there is no clear evidence that the samples of derris and cubé powders had depreciated in their toxicity. With 1.00 p.p.m. at 20°C., trout were killed by the various samples in an average time of thirty-six minutes—extremes of twenty-eight to fifty-four minutes. With 0.50 p.p.m. at 20°C., the average time was forty-nine minutes—extremes of thirty-two to seventy-seven. The older samples of derris, in three separate tests, gave periods varying from forty to seventy-seven minutes in a concentration of 0.50 p.p.m., and twenty-eight to fifty-four minutes with 1.00 p.p.m. Leonard (1939) found that derris powder lost approximately 43 per cent of its toxicity to goldfish after storage for six months, exposed to air in subdued light.

The results presented in Tables 3 and 4 show clearly that increased temperature greatly increases the toxic action.

The low concentration of 0.20 p.p.m proved lethal to trout at 5° and 20°C. Leonard (1939) found that 0.25 p.p.m. of derris (5 per cent) was not lethal to the common sunfish or bluegill at 15.5°C. Scheuring and Heuschman (reported by Leonard) killed trout with a concentration of 0.10 p.p.m. of derris, although it is suggested by Leonard that the derris had a greater rotenone content than 5 per cent. In summary, it is evident from the available data that various species of fish differ in greater or less degree in their resistance to the toxic action of rotenone.

Tests with Sample 3 of derris were extended by Hills and Tingley to include concentrations of 22, 44, 54, 73, 3, 110 and 220 p.p.m. The time required to kill trout in all these concentrations at 20°C., was approximately the same: 19, 13, 15, 13, 16 and 13 minutes, respectively. The solubility of rotenone in water is about 1 p.p.m. (Roark, 1933); saturation is attained, therefore, by a concentration of 20 p.p.m. of derris containing 5 per cent rotenone. Thus, in the above tests the concentration of rotenone probably remained constant at 1 p.p.m. and the time of death was consequently the same.

In certain experiments trout that had lost their equilibrium revived when placed in untreated water and appeared to regain their normal condition. To the contrary, Leonard (1939) observed that the common sunfish did not recover from the toxic action of rotenone once the fish had lost its equilibrium.

The varying resistance of different species of fish, the effect of chemical conditions of the water (as acidity), and the possible variation in the rotenone content of derris and cubé samples due to aging, combine to create a need for more experimental work. The action of rotenone in nature especially should be studied.

*Aquatic invertebrates*—The treatment of McCormick Lake with 1.33 p.p.m. of derris killed the planktonic Crustacea. Comparative counts of the crustacean plankters, as determined from fifteen-minute hauls with a No. 18 plankton net, are presented in Table 5. The counts were made in the same fashion as for the Crustacea recorded in Table 1. Certain rotifers, *Keratella cochlearis* and *Monostyla* sp., survived the treatment, as did species of Hydracarina. Similarly the treatment of Bill's Lake with 0.25 p.p.m. of derris on June 16, 1938, killed the planktonic Crustacea. These plankters were not found in the net hauls in McCormick Lake until the following spring, and in Bill's

**TABLE 5. COMPARATIVE COUNTS OF PLANKTONIC CRUSTACEA FROM McCORMICK LAKE, NOVA SCOTIA. (The plus signs indicate average counts less than one. The first two counts were made prior to the treatment with derris.)**

| | Plankton organism | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date of Collection** | *Diaphanosoma* | *Holopedium* | *Daphnia* | *Ceriodaphnia* | *Bosmina* | *Oxyurella* | *Polyphemus* | *Epischura* | *Diaptomus* | *Cyclops* | **Totals** |
| Aug. 3, 1937 | 135 | 119 | 115 | ---- | 5 | ---- | ---- | + | 1,623 | 55 | 2,055 |
| Aug. 6, 1937, a.m. | 215 | 100 | 64 | ---- | 2 | ---- | ---- | 2 | 1,116 | 58 | 1,557 |
| Aug. 6, 1937, p.m. | 1 | ---- | + | ---- | ---- | ---- | ---- | ---- | ---- | 1 | 2 |
| Aug. 8, 1937 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Sept. 3, 1937 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Oct. 6, 1937 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| May 30, 1938 | ---- | 69 | 2 | ---- | + | ---- | + | 14 | 468 | ---- | 553 |
| July 26, 1938 | 152 | 25 | 238 | 2 | 2 | ---- | ---- | 2 | 1,014 | + | 1,435 |
| Aug. 30, 1938 | 451 | 104 | 408 | 2 | 26 | ---- | ---- | ---- | 1,741 | 34 | 2,766 |
| Sept. 22, 1938 | 163 | 165 | 214 | 2 | 13 | + | ---- | ---- | 1,142 | 21 | 1,920 |
| Nov. 5, 1938 | ---- | 91 | 3 | ---- | 14 | ---- | ---- | ---- | 557 | 3 | 668 |

Lake they were not present by September 8, 1938. *Diaptomus birgei* died in all concentrations of derris (3 per cent) indicated in Table 3. Scheuring and Heuschmann (reported by Leonard) killed *Daphnia* with 0.50 p.p.m. of derris (5 per cent?).

Quantitative samples of the larger bottom organisms were secured by an Ekman dredge from Bill's Lake before and after the treatment with 0.25 p.p.m. of derris. The results (Table 6) show that this concentration of derris has no apparent effect on this community of bottom organisms, with the possible exception of *Hyalella knickerbockeri*. The smaller number of organisms secured after the treatment seems due chiefly to a decrease in the numbers of this amphipod. Bottom organisms (caddis fly, mayfly and stone fly nymphs, etc.) in Second River, Nova Scotia, were apparently unaffected by concentrations of derris toxic to brook trout and salmon parr (M'Gonigle and Smith, 1938). Hills and Tingley (unpublished experiments) found caddis fly larvae (Phryganeidae?) affected only after prolonged exposure (three days) to 0.50 and 1.00 p.p.m. of derris.

Leonard (1939) found that aquatic insects (*Argia* sp., *Acroneuria* sp., adult Hemiptera, Limnephilidae, *Tipula* sp.), crayfish (*Cambarus propinquus*), amphipods (*Hyalella knickerbockeri*), and snails (*Physa* sp.) were unaffected by 1.00 p.p.m. of derris in ninety-six hours. Scheuring and Heuschmann (reported by Leonard) killed *Chironomus* and *Gammarus* with 20 p.p.m. of derris.

**TABLE 6. COMPARATIVE COUNTS OF BOTTOM INVERTEBRATES FROM BILL'S LAKE, NEW BRUNSWICK, BASED ON DREDGE HAULS FROM TEN STATIONS.**

| Bottom organism | Totals for ten hauls of Ekman dredge. | |
|---|---|---|
| | June 14-15, 1938, before treatment with 0.25 p.p.m. of derris. | June 23-24, 1938, after treatment with 0.25 p.p.m. of derris. |
| Gastropoda | 122 | 152 |
| Sphaeriidae | 474 | 479 |
| Anisoptera | 4 | 7 |
| Zygoptera | 4 | 2 |
| Trichoptera | 39 | 46 |
| Chironomidae | 47 | 23 |
| *Corethra* larvae | 52 | 45 |
| *Corethra* pupae | 6 | 6 |
| Miscellaneous Insecta | 5 | 3 |
| *Hyalella knickerbockeri* | 136 | 82 |
| Hydracarina | 1 | 1 |
| Oligochaeta | 5 | 1 |
| Hirudinea | 8 | 5 |
| Planaria | 7 | 0 |
| Totals | 910 | 852 |

*Rooted aquatic vegetation and algae*—The treatment of McCormick and Bill's Lake with derris showed that various groups of aquatic plants were unaffected by rotenone. No changes in the phytoplankton, as shown by qualitative samples taken before and after the treatments, were evident. The phytoplankton included certain flagellates, as *Mallomonas, Synura, Dinobryon* and *Peridinium,* which are desig-

nated by some as Mastigophora. Space does not permit further enumeration of the species encountered in the plankton hauls.

## The Disappearance of Rotenone (Derris and Cubé) from Lakes

Rotenone appears to lose its toxicity quite rapidly under certain conditions. Solutions of rotenone in organic solvents change colour upon exposure to air and sunlight (Jones and Holler, 1931). There may be deposits of crystals containing decomposition products of rotenone which are innocuous to insects. Roark (1933), wrote: "Thin deposits of dry rotenone exposed to direct sunlight outdoors also change colour and lose their toxicity in the course of ten days or so. . . . In diffused light the decomposition of rotenone is not detectable." Leonard (1939) found that a solution of 1.00 p.p.m. of derris lost its toxicity to the common sunfish and bluegills between twenty-nine and forty hours, and that a stock suspension of 10,000 p.p.m. in a sealed container lost between 60 and 75 per cent of its toxicity in thirty-four days. Further, he found that a sample of derris powder lost 43 per cent of its toxicity to goldfish upon exposure to air and subdued light for six months.

After the treatment of McCormick Lake with 1.33 p.p.m. of derris the water remained toxic to fish for about one month. Five days after treatment two salmon (*Salmo salar*) and two trout (*Salvelinus fontinalis*) fingerlings were killed in ten to eighteen minutes when confined to a wire cage in the lake. After eleven days, one trout fingerling, one salmon fingerling, one dace (*Rhinichthys atronasus*) and one fallfish (*Leucosomus corporalis*) died under similar conditions. The trout died in twenty-six minutes, the salmon and dace in thirty-one minutes, and the fallfish in thirty-eight minutes. After thirty-five days, trout fingerlings lived in the McCormick Lake water for several hours, and it was presumed that the toxicity of the rotenone was fairly well dissipated by that time.

Bill's Lake, New Brunswick, was treated with 0.25 p.p.m. of derris on June 16, 1938. On September 7, 1938, killifish and lake chub lived indefinitely in water from the lake, indicating that the toxic action of the rotenone had disappeared.

Apparently no chemical test sufficiently delicate to detect rotenone in the low concentrations employed to kill fish has been discovered, although biological tests can be made easily. When small containers are used in such tests, care must be exercised to maintain a proper oxygen content in the water, or unreliable results will be obtained.

## Method of Application of Rotenone (Derris and Cubé)

In McCormick and Bill's Lakes the derris was distributed by towing the powder, contained in gunny sacks, behind row boats. Since the derris powder cakes from contact with water, it was necessary to knead it with the hand to insure a sufficiently rapid distribution. In the treatment of Second River—a stream 10 to 20 feet in width—

mixing the powder in slow-flowing pools above riffles was found most satisfactory. Eschmeyer (1937, 1938) distributed derris by first making a suspension in water and pouring this mixture from a boat driven by motor. In certain lakes he used dynamite to facilitate mixing.

## Summary


1. Three p.p.m. of copper sulphate ($CuSO_4 \cdot 5H_2O$) proved effective in destroying fish in four Nova Scotian lakes containing acid waters.

2. Copper sulphate in the above concentration destroyed almost all phyto- and zooplankters, as well as the bottom fauna. The rooted aquatic vegetation was, for the most part, unaffected. About a year elapsed before the plankton and aquatic insect larvae and nymphs returned in quantity. Mollusks have not repopulated the lakes.

3. Apparently much of the copper is removed from solution in acid waters by combination with organic matter. Considerable copper remains in the lake waters for some time, but there is evidence that much is in a combined rather than in the toxic ionic form.

4. Under experimental conditions derris and cubé powders containing 3 and 5 per cent rotenone killed yearling trout in a concentration as low as 0.20 p.p.m. (all concentrations based on 5 per cent rotenone content) at 5° and 20°C. Derris containing 3 per cent rotenone killed suckers and lake chubs at 0.20 p.p.m. at approximately 10°C., although survivals of suckers indicated that this concentration was the borderline for effective toxic action.

5. In nature, 0.25 p.p.m. of derris containing 5 per cent rotenone killed eels, lake chubs, sticklebacks, black bass and white perch in a small lake with acid waters. A second treatment with 1 p.p.m. showed a small survival of eels, lake chubs and sticklebacks from the earlier treatment. Treatment of another small lake with 1.33 p.p.m. killed all brook trout.

6. The retention of samples of derris and cubé powders up to three years in dry condition did not affect their toxicity to brook trout.

7. Increased temperature speeded greatly the action of rotenone as contained in derris and cubé powders.

8. Brook trout that had lost their equilibrium in waters treated with derris and cubé revived when placed in untreated water.

9. In nature, concentrations of rotenone, sufficient to kill fish, largely destroyed the planktonic Crustacea, and possibly affected amphipods (*Hyalella*). Insect larvae and nymphs, mollusks, hydracarina, certain rotifers, algae and rooted aquatics were apparently unaffected under these conditions. Prolonged exposure to concentrations of 0.50 and 1.00 p.p.m. of derris (5 per cent rotenone) killed caddis larvae under experimental conditions.

10. In a small lake treated with 1.33 p.p.m. of derris (5 per cent rotenone), the waters remained toxic to fish for approximately one month.

## Literature Cited

Caird, J. M.
1905. The copper sulphate treatment for algae at Middletown, N. Y. Eng. News, Vol. 53, pp. 33-34.

Callan, T., and J. A. R. Henderson
1929. A new reagent for the colorimetric determination of minute amounts of copper. Analyst, Vol. 54, pp. 650-653.

Carpenter, K. E.
1927. The lethal action of soluble metallic salts on fishes. Brit. Jour. Exp. Biol., Vol. 4, pp. 378-390.

Carroll, E.
1904. Treatment of reservoir of the Butte Water Co., with copper sulphate. Eng. News, Vol. 52, pp. 141-143.

Catt, James
1934. Copper sulphate in the elimination of coarse fish. Trans. Amer. Fish. Soc., 1934, Vol. 64, pp. 276-280.

Ellms, J. W.
1905. Behavior and uses of copper sulphate in the purification of hard and turbid waters. Jour. New England Water Works Assoc., Vol. 19, pp. 496-503.

Ellis, M. M.
1937. Detection and measurement of stream pollution. Bull. U. S. Bur. Fish., Vol. 48, pp. 365-437.

Eschmeyer, R. W.
1937. Some characteristics of a population of stunted perch. Pap. Mich. Acad. Sci. Art. Let., Vol. 22 (1936), pp. 613-628.
1938. Further studies of perch populations. Pap. Mich. Acad. Sci. Art. Let., Vol. 23, (1937), pp. 611-631.

Jones, H. A., and H. L. Holler
1931. The "yellow compounds" resulting from the decomposition of rotenone in solution. Jour. Amer. Chem. Soc., Vol. 53, pp. 2320-2324.

Leonard, J. W.
1939. Notes on the use of derris as a fish poison. Trans. Amer. Fish Soc., 1938, Vol. 68, pp. 269-279.

M'Gonigle, R. H., and M. W. Smith
1938. Cobequid hatchery—Fish production in Second River, and a new method of disease control. Prog. Fish Culturist, U. S. Bur. Fish., Mem. I-131, No. 38, pp. 5-11.

Moore, G. T., and K. F. Kellerman
1904. A method of destroying or preventing the growth of algae and certain pathogenic bacteria in water supplies. U. S. Dept. Agr., Bur. Plant. Ind., Bull. 64, pp. 1-44.
1905. Copper as an algicide and disinfectant in water supplies. U. S. Dept. Agr., Bur. Plant. Ind., Bull. 76, pp. 1-55.

Moore, J. P.
1923. The control of blood-sucking leeches, with an account of the leeches of Palisades Interstate Park. Roosevelt Wild Life Bull., Vol. 2, pp. 1-53.

Moseley, H. W., A. G. Rohmer, and M. C. Moore
1934. Use of sodium diethyldithiocarbamate in the determination of minute amounts of copper. Science, Vol. 79, (No. 2057), June 1, 1934.

Powers, E. B.
1917. The goldfish (*Carassius carassius*) as a test animal in the study of toxicity. Ill. Biol. Mon., Vol. 4, pp. 1-73.

Riley, G. A.
1937. The significance of the Mississippi River drainage for biological conditions in the northern Gulf of Mexico. Jour. Mar. Res., Vol. 1, pp. 60-74.

Roark, R. C.
1933. Rotenone. In. Eng. Chem., Vol. 25, pp. 639-642.

Scheuring, L., und O. Heuschmann
1935. Ueber die Giftwirkung von Derris Präparaten auf Fische. Allg. Fisch.-Ztg., Bd. 24.

Smith, G. M.
1924. Ecology of plankton algae in the Palisades Interstate Park, including the relation of control methods to fish culture. Roosevelt Wild Life Bull., Vol. 2, pp. 93-195.

Smith, H. E.
1905. The taxicology of copper and its relation to the copper treatment of water. Journ. New England Water Works Assoc., Vol. 19, pp. 491-496.

Smith, M. W.
1935. The use of copper sulphate for eradicating the predatory fish population of a lake. Trans. Amer. Fish. Soc., 1935, Vol. 65, pp. 101-113.
1938. A preliminary account of the fish population in certain Nova Scotian Lakes. Trans. Amer. Fish Soc., 1937, Vol. 67, pp. 178-183.
1938. A survey of lake Jesse, Nova Scotia. Proc. N. S. Inst. Sci., Vol. 18, pp. 253-263.

Topley, W. W. C., and G. S. Wilson
1936. The principles of bacteriology and immunity. 2nd. Ed., Edward Arnold and Co., London, Part I, pp. 1-225.

# ARTIFICIAL PROPAGATION AND THE MANAGEMENT OF TROUT WATERS

H. S. Davis
*U. S. Bureau of Fisheries, Washington, D. C.*

### Abstract

The effectiveness of artificial stocking as compared with natural propagation is one of the most fundamental problems in fish management. Recent studies show that natural spawning is much more efficient than was formerly supposed, the hatch often comparing favorably with that at hatcheries. Good results from artificial stocking have been obtained in so-called barren waters and with the use of large fish. Frequently, however, stocking has been a failure and whether it has been generally successful is still problematical. Results of some recent studies on the effects of stocking are summarized. It is believed that a major cause of the failure of stocking is the lack of complete correspondence between the ecological requirements of the fish and the environment. The great need for further studies is stressed.

## Introduction

One of the most fundamental problems in the management of trout waters is the effectiveness of artificial stocking as compared with natural propagation. Until quite recently the problem was airily dismissed by the fish-culturist with the assertion that under natural propagation only about 5 per cent of the eggs hatched while in the hatchery only 5 per cent failed to hatch. This statement, accepted without reserve by the majority of anglers, led to the demand for more and more hatcheries and the one remedy for poor fishing was believed to be the planting of more and larger fish.

In recent years, however, many anglers and conservationists have begun to realize that heavier stocking does not necessarily mean more fish for the angler and that in some situations, at least, the results have been quite the opposite. It is evident that artificial stocking is not a universal panacea for poor fishing and that the problem as to the effects of stocking is much more complex than the older fish-culturists would have us believe. It is now apparent that only through carefully planned studies carried on systematically over a period of years can we hope to arrive at any sound conclusions as to the value of artificial stocking in maintaining the trout population.

In my opinion a great mystery in the history of fish culture is the fact that for years practically no attempt was made to learn the results of stocking and that even today, although a start has been made in this field, the personnel and funds available for this work are pitifully small when compared with the large and constantly increasing amounts expended on fish hatcheries. In the hope that it will stimulate greater interest in this field I have attempted to summarize briefly the results of work already done so that we can appreciate better our present position and the crying need for further studies.

## Efficiency of Natural Propagation

Before discussing the results of artificial stocking let us turn for a moment to some recent studies on the efficiency of natural propagation. The complacency of those who have assumed without question that artificial propagation is far superior to the natural process was shattered rudely by the investigations of Hobbs (1937) who found that in New Zealand streams the natural reproduction of salmon and trout is extremely efficient. In both brown and rainbow trout over 99 per cent of the eggs taken from the nests contained embryos. He found also that in the brown trout at least 97.5 per cent of the eggs lodged in the nests at the time of spawning. Furthermore, the hatch in brown trout streams where the nests were undisturbed ranged from 95 to 97 per cent. It is a very exceptional hatchery that can make as good a showing.

There were, of course, exceptional losses in some instances, caused by floods, superimposition of eggs by later spawners, and other accidents, but these losses were usually not serious.

It may be that conditions in the streams investigated by Hobbs were exceptionally favorable for spawning but, as a matter of fact, his results do not disagree materially with those of less complete studies made in this country. White (1930), for instance, found that of 452 eggs taken from a brook trout nest on Prince Edward Island 347, or 77 per cent, hatched. The losses included eggs that died from injuries received when they were removed from the gravel. In another test, naturally fertilized eggs placed on a screen yielded a hatch of 66 per cent.

Samples of brook trout eggs collected by Hazzard (1932) from New York streams also showed a high percentage of fertilization. Twenty-one nests contained an average of 201 eyed eggs. The percentage of eggs containing embryos varied from 27 to 98.5 with an average of 79.8. In all but one nest more than 69 per cent of the eggs were found to be alive. From these studies it must be apparent to all but the most prejudiced that the widely held belief in the inefficiency of natural spawning is largely unwarranted. Under suitable conditions the results of natural spawning compare favorably with those obtained by the average hatchery.

But if we grant that natural propagation is more efficient than was believed formerly it does not necessarily follow that nothing is gained through artificial propagation. The newly-hatched fish must lead a perilous existence until it reaches a catchable size and it may be that the protection and the abundance of food afforded by the hatchery will turn the balance in favor of artificial propagation.

## Results of Artificial Stocking of Streams

Unfortunately, we have little definite information on the propor-

tion of wild fry that reach maturity, but it is evidently quite small. We do know, however, that enough trout may survive to provide a goodly number of fish for the angler, even in heavily fished streams. On the other hand, when we examine critically the results of artificial stocking we find that here, too, there is remarkably little information available.

For years fish-culturists have pointed with justifiable pride to the results achieved in stocking so-called barren waters. There can be no question of the success attained, but the stocking of waters that are rich in food and without a natural stock of fish is quite a different matter from stocking streams and lakes that from time immemorial have been inhabited by trout and other fish. The evidence as to the results from stocking waters that already contain fish is far from conclusive for in many instances artificial stocking has indubitably ended in utter failure.

One of the few heavily stocked streams on which we have a complete record of the fish taken by anglers for several years in succession is Furnace Brook in Vermont. Here a record of the annual catch has been kept since 1935 (Lord, 1936). This stream contains both brook and rainbow trout but in recent years it has been stocked only with the former species. With the exception of 1934, the stream has been stocked with approximately 10,000 3-inch fingerlings each year since 1933. In addition, from 2,400 to 5,200 yearlings were planted also in the stream from 1934 to 1937. In spite of the heavy stocking we find that the catch of brook trout has decreased gradually each year from a total of 5,649 fish in 1935 to 4,371 in 1936, and 4,007 in 1937. In 1938 there was a sudden decrease to a total of only 1,768 fish taken during the season.

During this time, however, the rainbow trout, which is entirely dependent on natural propagation, has held its own much better than the brook trout. In 1935 a total of 2,942 rainbow trout was taken by anglers. This species also showed a slight decrease to 2,624 in 1936 and 2,378 in 1937, but in 1938, when there was a sharp decrease in the catch of brook trout, there was an increase to 2,879 in the number of rainbow trout. On a percentage basis the picture is even more striking since from 1935 to 1937 the proportion of rainbow trout in the total yield was quite constant, ranging from 34 to 37 per cent. In 1938, however, there was a complete reversal in the relative numbers of brook and rainbow trout, the brook trout now forming only 38.3 per cent of the catch while the rainbow trout made up the remaining 61.7 per cent.

The marked decrease in the number of brook trout taken in 1938 may have been due to an exceptionally severe flood during the preceding January but, if so, it indicates that the rainbow trout are better able to contend with flood conditions than are the brook trout.

Big Spring Creek in Virginia is a small spring-fed stream that has

been operated as an experimental stream for several years. This stream is so exceptionally rich in food that 5-inch fingerling rainbow trout planted in July and August reach a length of 8 to 10 inches the following summer. According to Surber (1936), although the stream has been stocked heavily with marked fingerlings each year the percentage of hatchery fish in the total catch was only 8.3 in 1933, 7.5 in 1934, 6.0 in 1935 and 1.5 in 1936. It is interesting to note that an increase of 100 per cent in the stocking rate in 1935 was followed by a marked decrease in the number of hatchery-reared fish caught the following year although the total number of fish taken was only slightly less than in previous years.

St. Marys River, in the George Washington National Forest in Virginia, also operated as a test stream by the Bureau of Fisheries, presents quite different conditions. This river, which is representative of mountain streams in that region, is characterized by a limited food supply and is subject to great fluctuations in volume. St. Marys River was stocked by the Bureau with 3- to 5-inch fingerlings in 1935 and again in 1936. Results during the fishing season of 1936 were so poor that it was decided to keep the stream closed to fishing during 1937. However, samples of the trout population were taken by angling several times during the summer, the fish being returned to the stream after examination. In this way 492 fish were caught and examined, of which number 310 (including 115 marked fish) were brook trout and 282 were rainbow trout (including 180 marked fish). Among the marked brook trout those planted in 1935 greatly predominated (in the ratio, 84:31), while among the rainbow trout the 1935 plant lagged behind that of 1936 (ratio of 21:159).

During the fishing season of 1938 the total catch in the St. Marys River was 113 brook trout and 189 rainbow trout. Only thirteen (11.5 per cent) of the brook trout were hatchery fish but eighty-one rainbow trout, or 48.8 per cent, had been planted in the stream. With both brook and rainbow trout the great majority of the hatchery fish caught had been planted in 1936. It is worthy of note that although the St. Marys is a comparatively small stream some of the rainbow trout had stayed in the experimental section from two to three years. It should also be noted that the stream was stocked in 1935 and 1936 with a total of 3,601 brook trout and 4,670 rainbow trout. With both species the heavier stocking was in 1935. No fish were planted in 1937.

A notable example of the failure of artificial stocking to influence the catch is afforded by Squaw Creek in the Shasta National Forest, California. A check of anglers' creels in this stream in the summer of 1937 (Needham, 1938) showed a total catch of 2,504 trout. Of this number 2,497 were rainbow trout and only 7 were brown trout. In the preceding years (1932 to 1936) the State planted in this stream approximately 20,000 eastern brook trout, 134,000 rainbow trout and 130,000 brown trout.

## Results of Artificial Stocking of Lakes

Reports on the stocking of lakes appear, on the whole, to be more favorable than do those on the stocking of streams. I have referred previously to barren lakes hundreds of which have been stocked with notable success.

One of the most interesting experiments is that reported by Dahl (1934). Very complete records have been kept since 1914 of the annual trout yield of a small Norwegian lake with an area of approximately 149 acres. In these experiments the total catch for each year-class was recorded even though the fish were not all taken during the same year. The average catch of eight year-classes without stocking, or with the stocking with small fry through the ice, was 108 fish with an average aggregate weight of 119 pounds. Stocking with 4,000 fry through the ice about the middle of May failed to increase the catch of a year-class. Stocking with 4,000 to 7,000 small fingerlings later in the season resulted in a marked increase in the number of fish taken and also in the total weight. The average catch under these conditions was 207 fish with an average total weight of 264 pounds. Apparently 100 fish out of about 5,700 fingerlings reached a sufficient size to be taken in the nets—a survival of less than 2 per cent. In this lake natural spawning was evidently reduced to a minimum since the stock of large trout was so depleted by intensive netting that very few were left to spawn. Nevertheless, the results indicate that even in a very intensively fished lake natural propagation may supply at least 50 per cent of the catch.

A quite different picture is presented by Fish Lake in the Umpqua National Forest in Oregon. Nearly complete records of the catch in this lake in 1937 (Needham and Cliff, 1938) show a total catch of 5,946 fish. Of this total 5,878 fish, or about 99 per cent, were rainbow trout and only 68 were eastern brook trout. According to stocking records for the three preceding years 20,000 cutthroat and 40,000 eastern brook trout were planted in the lake, but no rainbow trout were planted until 1937.

## Survival of Trout of Various Sizes after Planting

It is possible that the cases I have cited present too black a picture and that artificial stocking is more efficient than these results would indicate. Undoubtedly a great deal depends on the size of the fish when they are planted, although there is a great difference of opinion on this question. There can be no doubt that stocking with legal-sized trout to be caught within a short time has been very successful. In this way good fishing has been provided in waters where there had been little or none. The planting of large fish in intensively fished waters is increasing rapidly. Although rearing trout to a length of 8 to 10 inches is expensive, it is believed by many fish-culturists that it is the only method that can be relied upon to produce results. But

even with the use of large fish it would appear that more trout are lost than is usually realized. As a result of tagging 15,875 legal trout planted in Connecticut waters shortly before or during the fishing season, Cobb (1933) estimated that not over 50 per cent of the fish planted were taken by anglers.

When fish are planted in the fall or early winter the losses are much greater. Nesbit and Kitson (1937) found that in streams anglers took 5.2 fish that had been planted in the spring for every single fish planted in the fall. In ponds, however, the fish planted in the fall made a much better showing. The ratio in the catch was 1.9 spring-planted fish to each fish planted in the fall. Furnace Brook, previously mentioned, also provides an excellent example of the futility of planting large trout in the fall. In the late summer of 1936, 5,200 yearling brook trout were planted in this stream. These fish were in excellent condition when planted and were well scattered along the stream, yet only 10 per cent appeared in the catch the following season. Again in the fall of 1937, 5,200 yearling trout were planted in Furnace Brook but the returns the following season were even more disappointing since less than 2 per cent of these fish were taken by anglers. Preliminary reports from experiments now under way in the Pisgah National Forest, North Carolina, indicate that even in this mild climate the odds are greatly in favor of fish planted in the spring.

No one doubts that the mortality among fingerlings after planting is usually quite high, as indicated by Embody's planting table, but we still do not know if the losses among hatchery fish when planted properly are materially greater than among wild fish of the same size. The extensive experiments of White (1924, 1926, 1929) in Canadian streams indicate a mortality of 50 to 80 per cent during the first summer. It is notable that in his later experiments he found the mortality to be much less with light than with heavy stocking. On the other hand, preliminary experiments by Needham on Convict Creek indicate that in this area hatchery fish of 2 inches and over in length have a high survival in natural waters during the first summer. It must be remembered, however, that these experiments cover only a period of about three months during the most favorable part of the year.

## General Conclusions

Some of you no doubt have followed with interest the recent controversy in the *Salmon and Trout Magazine* on the ultimate results of stocking streams with hatchery fish. C. Stratton Gerrish (1935, 1936) maintained that many English streams contain two distinct types of trout: a fast-growing strain that is short-lived and a more slowly growing strain that eventually reaches a much larger size and greater age. The fast-growing strain is believed to be composed of hatchery fish and since, according to Gerrish, they rarely spawn more than once, the ultimate result of artificial stocking is to lower the trout population instead of increasing it. Naturally, these conclusions have been criti-

cized severely by other workers, one of whom, Mottram (1936), conceded the presence of two strains of fish in artificially stocked streams but advanced quite another explanation which has interesting possibilities. Mottram contended that the strain of trout normally inhabiting streams is much different from the strain that has long been accustomed to life in lakes. Trout adapted to life in lakes are long and comparatively slender while the typical stream fish is short and thick. The latter is built for maintaining itself easily in running water, the former for wandering about in still water. Mottram maintained that the Loch Leven trout, which is a lake fish, has been used very largely in developing hatchery strains of brown trout and that consequently hatchery fish are ill adapted to life in streams.

There is certainly food for thought in this theory of Dr. Mottram although it obviously cannot be accepted without further evidence in its favor. There is no doubt in my mind that in the future we must devote more attention to the adaptability of hatchery fish to the particular environment in which they are placed. This principle has, of course, been recognized with regard to species but little attention has been paid to intraspecific differences. Yet there is much evidence that within each species of trout there are more or less distinct races or strains that are adapted to different conditions. These differences may not be evident to the taxonomist but they are present, nevertheless, as for example in the sea-run races of rainbow and brook trout. The rainbow trout is usually considered the most migratory of the trout group and yet we are now finding that resident strains have become established in small streams in the East and I have no doubt that similar strains will be found in western waters.

I believe that in the lack of complete adjustment between fish and environment lies the explanation of many of the failures of artificial stocking. Another frequent cause of failure is the lack of proper care in planting. Possibly some rational explanation can be advanced for the all too frequent practice of dumping a truckload of trout, which have been carefully tended in the hatchery, into a stream at any spot that happens to be most convenient, but I have failed to find it. It would seem that common sense should dictate that as much care and thought be devoted to the final disposal of trout as to rearing them.

The most urgent need at the present time, however, is the comprehensive studies on the life history, growth and survival of both wild and hatchery fish. If it is true, as claimed by some authorities, that trout reared in the hatchery are hopelessly handicapped when released in natural waters, and that we should plant small fingerlings or fry that have not been exposed for long to the demoralizing effects of hatchery life, the sooner we know it the better. If it is true, as maintained by others, that our only salvation is to plant large trout, this fact also should be determined. If, on the other hand, the greatest possibilities lie in promoting natural propagation this principle again should be established clearly. Much can be said for all three methods

and doubtless each has its value under proper conditions. Only by obtaining the facts can we hope to justify management as the one means of getting the most out of our trout waters.

## Literature Cited

Cobb, E. W.
1933. Results of trout tagging to determine migration and results from plants made. Trans. Am. Fish. Soc., Vol. 63, pp. 308-312.

Dahl, Knut
1934. Does trout stocking pay? Salmon and Trout Magazine, No. 74, pp. 18-26.

Gerrish, C. S.
1935. Hatchery stock and the trout streams. Are farm fish short lived? Salmon and Trout Magazine, No. 81, pp. 331-344.
1936. The value of hatchery trout for stocking rivers. Salmon and Trout Magazine, No. 84, pp. 245-254.

Hazzard, A. S.
1932. Some phases of the life history of the eastern brook trout, *Salvelinus fontinalis* Mitchill. Trans. Am. Fish. Soc., Vol. 62, pp. 344-350.

Hobbs, D. F.
1937. Natural reproduction of quinnat salmon, brown and rainbow trout in certain New Zealand waters. New Zealand Marine Department, Fisheries Bull., No. 6, pp. 1-104.

Lord, R. F.
1936. The "test stream" and fish management. Proceedings, First North American Wildlife Conference, pp. 453-460.

Mottram, J. C.
1936. The value of hatchery trout for stocking waters. Salmon and Trout Magazine, No. 82, pp. 14-34.

Needham, Paul R.
1938. Trout streams. Comstock Publishing Company, Ithaca, N. Y., 233 pp.

Needham, P. R. and E. P. Cliff
1938. Trout production in Fish Lake, Umpqua National Forest, 1937. Progressive Fish Culturist (U. S. Bureau of Fisheries, Mem. I—131), No. 40, pp. 28-40.

Nesbit, R. A. and J. A. Kitson
1937. Some results of trout tagging in Massachusetts. Copeia, 1937, No. 3, pp. 168-172.

Surber, Eugene W.
1936. Rainbow trout and bottom fauna production in one mile of stream. Trans. Am. Fish. Soc., Vol. 66, pp. 193-202.

White, H. C.
1924. A quantitative determination of the number of survivors from planting 5,000 trout fry in each of two streams. Contrib., Can. Biol., Vol. II, pp. 137-149.

1926. A preliminary report on trout investigations in Forbes Brook in 1925 and 1926. Contrib., Can. Biol., N.S., Vol. 3, pp. 367-375.
1929. Trout fry planting experiments in Forbes Brook, P.E.I. in 1928. Contrib., Can. Biol., N.S., Vol. 5, pp. 203-212.

## Discussion

Mr. H. H. MacKay: I should like to ask Dr. Davis if he found any competition for food as between the speckled trout and the rainbow trout, and if he noticed whether the rainbow trout were at all predatory in the streams to which he referred.

Dr. Davis: Undoubtedly they compete for food. Practically the only food in Furnace Brook consists of aquatic insects; there are no crustacea of any sort. But as to predation, I think the brook trout is more predatory for its size than is the rainbow trout. We have, however, no direct evidence bearing on that question. There is no actual evidence that the brook trout is being crowded out by the rainbow. I think the evidence all tends to show that the rainbow trout are surviving simply because they are adapted to the particular conditions in that brook, which has always been considered one of the finest brook trout streams in New England.

Mr. Glen C. Leach: Dr. Davis has presented a remarkable paper, but on the other hand I feel, and naturally so, that artificial propagation of trout is far superior to natural reproduction. I believe that frequently we have been none too careful in distributing our artificially propagated fish, and that this carelessness has resulted in giving a "black eye" to the work of propagation. So far as the Bureau of Fisheries is concerned, a number of years ago we delivered our fish to "Tom, Dick and Harry," who came to the railway stations and took them away. We had absolutely no knowledge as to where they were planting them. Under such conditions the artificial stocking of streams gained a bad reputation. On the other hand, I feel that Dr. Davis in his report here is more or less concentrating on certain streams that are not suitable for brook trout. If it were not for the work of the states and the Bureau of Fisheries there would not be any natural propagation; the fish would be caught out. I believe the states and the Bureau are getting results.

In Colorado originally there were no brook trout. The species has been introduced into that state. Rainbow trout were taken from native streams and introduced in the east. Loch Leven trout were brought from Europe and introduced into Montana waters and other waters in the West. It is my view that we owe much to the artificial propagation of fish. The states are now giving careful study to the question of artificial propagation and are taking the stand that they should distribute their own fish. They are making scientific investigations into the conditions affecting their streams before fish are introduced into them. They are preparing stocking programs. It is necessary that the states and the Federal Bureau of Fisheries take more interest in the scientific study of streams and of stream management and especially in investigation to see whether or not streams are producing enough natural food to support the fish.

It may be that in the eastern states where the population is crowded it will be necessary to introduce larger fish. That condition does not prevail so much in the West, where the streams are protected better and are not affected by agricultural activity. For a time, at least, in the western section of the country I believe there will be a proper survival rate where the waters are stocked with smaller fish.

Dr. Davis: I hope no one will get the impression from my paper that I was arguing against artificial propagation. I desired merely to point out that artificial propagation has its faults. Undoubtedly in many cases the poor results which have followed artificial stocking can be explained easily and can be remedied. The main purpose of my paper was to point out the necessity of getting the facts so that we can stock fish to the best advantage and get the best possible

results. I do not think there is any way in which that can be done without, as Mr. Leach has said, a careful scientific study of a large number of streams in various parts of the country.

MR. B. O. WEBSTER: I have been engaged in the artificial propagation of fish for many years, and naturally I was pleased to hear Mr. Leach's remarks. Today Wisconsin is making very exhaustive studies and investigations with respect to all phases of fish propagation. These investigations have been carried on over the last two or three years. What I am about to say does not apply just to brook trout or to trout streams, but it will give you some general idea of the efficiency of natural reproduction.

In the collection of wall-eyed pike eggs in the state of Wisconsin we discovered that female wall-eyed pike were depositing their eggs right along the shore near the hatchery. From the examination of these eggs after they had been spawned we found that a very large percentage of eggs had been fertilized. A certain portion of them was set off with a screen and a considerable number hatched out. After the hatching something happened to the fry, and it was absolutely impossible in that enclosure to find one single live wall-eyed pike from the large number of fertilized eggs from natural spawning.

In our investigations of muskellunge, our biologist informed me that he was discovering that an enormous percentage of eggs that were deposited naturally was becoming fertilized. I said to him: "That study will soon indicate that there is no occasion for our continuing the difficult process of the propagation of muskellunge." He replied: "That does not follow." Using the same methods he found the same results with these muskellunge that he had found with the wall-eyed pike, namely that very few of the fish survived after they had hatched out. Of course these observations are not conclusive so far as actual conditions are concerned, because the work has not gone far enough.

MR. C. M. BLAKE: It seems to me that the angler is a very poor source of reliable data. It is difficult to obtain accurate records as to what the anglers do catch. The vast majority of them keep the larger fish and throw the little ones back, and there would be no record whatever of those smaller fish.

MR. GEORGE MCCLOUD: I notice that in most of the investigations with regard to hatchery trout and natural propagation in the streams the hatchery trout are planted in the stream in which the study of the natural propagation is being made. I should think that if a satisfactory check on natural propagation is to be had all hatchery trout should be kept out of those waters. I was wondering if anybody would suggest that in any such program the watersheds in question be not stocked with trout at all, in order that a true picture of the extent of natural reproduction might be obtained.

THE CHAIRMAN: I have the impression that that has been done, hasn't it, Dr. Davis?

DR. DAVIS: No, not exactly in that way. In some of our experiments we suspend the stocking of the streams for two or three years, in order to compare the results in the same streams under artificial stocking and without artificial stocking.

THE CHAIRMAN: In studying the results of stocking smallmouth black bass in our Ohio streams we also have some figures on results. We have tagged a great many individuals, and we find that although there might not be high recovery in a given area where the fish are stocked there has been an extensive downstream migration. Many of the fish are recovered out of the territory in which they were placed. Did you ever find any evidence of migration out of the area in which the fish were placed, thus explaining your low percentage of recovery?

DR. DAVIS: The experimental section in Furnace Brook is shut off from the rest of the stream below by a dam and falls which are practically impassable. There is a great deal of fishing done in the stream below. Most of the fish

caught there are rainbow trout. Very few brook trout were taken below our experimental section, so that we could not explain the small number of brook trout taken there as due to the fact that they have gone downstream.

In one stream in Virginia, the St. Mary's River, we have good evidence that a great many of the rainbow trout go downstream. The records show that in the experimental section the percentage of hatchery fish caught is greater among the rainbow trout than it is among the brook trout, and yet we know that the rainbow trout are going downstream to a much greater extent than the brook trout.

THE CHAIRMAN: Where you assume mortality, have you recovered the bodies of the fish?

DR. DAVIS: No, we are not assuming mortality. We say only that we do not know what happened; the fish are not there, that is all. We believe it was mortality.

THE CHAIRMAN: In one of our Ohio streams where we were getting a very high percentage of returns we fenced off the area and actually found about a 52 per cent mortality. We found the dead fish.

DR. DAVIS: Last fall we did find a number of stranded dead fish, but otherwise we have had no evidence of mortality. Of course that fact does not affect the records which I gave.

# *SCYPHIDIA MICROPTERI*, A NEW PROTOZOAN PARASITE OF LARGEMOUTH AND SMALLMOUTH BLACK BASS[1]

EUGENE W. SURBER

*U. S. Bureau of Fisheries, Leetown, West Virginia*

ABSTRACT

A small urn-shaped peritrichous protozoan, apparently an undescribed species, was found on the gills and bodies of largemouth and smallmouth black bass in ponds at Leetown, West Virginia. A heavy mortality among a lot of fingerling largemouth bass probably resulted from suffocation due to the organisms on the gills. Specimens of the parasite, preserved in formalin, measured about 57 microns in length and 24 microns in maximum width. The base of the animal consists of a circular disc about 6 microns in diameter. No evidence was found that the sucker-like attachment disc penetrated the epidermal cells of the host causing necrotic tissue. The anterior or upper end of the animal has a ciliary disc and two rows of cilia. The body is without cilia and is annulated. The macronucleus is very large, has the shape of an inverted cone and occupies much of the lower half of the body. The small micronucleus apparently lies in the slightly concave surface of the upper part of the macronucleus, although there is doubt on this point. This new species was named *Scyphidia micropteri* after *Micropterus*, the generic name of the smallmouth black bass, one of its hosts. The species recently was found by Dr. H. S. Davis on gills of largemouth black bass collected in Radnor Lake, Tennessee, which indicates a wide geographical distribution of the parasite.

## INTRODUCTION

A report was received August 21, 1938, that a certain lot of fingerling largemouth black bass, *Huro salmoides*, at the Leetown (West Virginia) Station had stopped eating. Large numbers of an unknown peritrichous protozoan were found attached to the gill filaments. There were also a few gyrodactylid worms and *Cyclochaeta* present, but the marked abundance of the peritrichous protozoa commanded special attention. Since the lot of bass was not large or valuable, it was decided to allow them to remain untreated in order to determine whether the unknown organisms could become abundant enough actually to kill the fish. On August 24, 1938, 1,053, or nearly the entire lot, died. The same pool contained large numbers of golden shiners, *Notemigonus crysoleucas*, but the *Scyphidia* found on the gills of the largemouth black bass were totally absent from the gills of the golden shiner. The shiners were more heavily infested with gyrodactylid worms than were the largemouth black bass. The species of *Scyphidia* described here was found on smallmouth, *Micropterus dolomieu*, and largemouth black bass in adjacent pools at Leetown, West Virginia. Dr. H. S. Davis found specimens of the same species on the gills of largemouth black bass collected on May 5, 1939, in Radnor Lake, Tennessee, which indicates that the species may be widely distributed.

---

[1]Published by permission of the Commissioner of Fisheries.

## Identification of the Parasite

The name, *Scyphidia micropteri,* is proposed for the species described in this paper, after the generic name of one of its hosts, the smallmouth black bass, *Micropterus dolomieu* Lacépède. No evidence was found that the form had been described previously. I was of the opinion for some time that the species was *Scyphidia amoebea* described by Grenfell (1887). However, he stated that "in the majority of cases the animal is attached by pseudopodia. These may take the form of a single lobe or two simple lobes, and so on up to several highly complicated processes." Grenfell also stated that the species divides by transverse fission, while I have observed three specimens dividing by longitudinal fission. The figures which he gave to illustrate his species do not resemble the species with which we are concerned, but Roux (1901) gave a careful figure which showed pseudopodia at the base, as well as a row of central cilia. Although a thin ridge, or band, thicker than others of the annulated body is sometimes present (possibly always present but not discernible) just above the macronucleus, a band of central cilia has never been observed in the species found at Leetown. Not a single specimen has been observed with pseudopodia at the base, or scopula, which was always disc-shaped.

Kahl (1935, p. 667) placed *Vorticella*-like organisms, which do not possess a stalk even in the adult stage, in a new family, Scyphidiidae. The genus *Glossatella* is included in this new family, and under *Glossatella* he placed those Scyphidiidae, like *Scyphidia micropteri,* which occur on fish or amphibians and which have the nucleus in the lower part of the body. In the present paper, however, the newly described species has been referred to the genus *Scyphidia* since most protozoologists include in the genus those solitary animalcules of the following description: medium to large sized, form variable, cylindrical or urn-shaped; highly contractile; adherent posteriorly to foreign bodies by means of a specially developed acetabuliform organ of attachment; surface of the integument often transversely or obliquely furrowed; body without cilia; oral end with a ciliary disc provided with two ciliary girdles running in a contra-clockwise spiral; margin of the peristome padded, rarely turned down; peristomial groove continued as a vestibule, with the cytostome at its end; position of contractile vacuole variable; macronucleus of variable form.

With the exception of Kahl (1935), protozoologists in general consider the presence of an undulating membrane one of the principal characters of the genus *Glossatella.*

In my observations of *Scyphidia micropteri,* I have been unable to detect necrotic tissue on the host in the vicinity of the points of attachment of the parasite. It seems probable that the organism merely finds the gills of black bass convenient for attaching itself and feeds primarily upon matter passed through the gill chambers during the respiratory activities of the fish. The distribution of the parasite is not con-

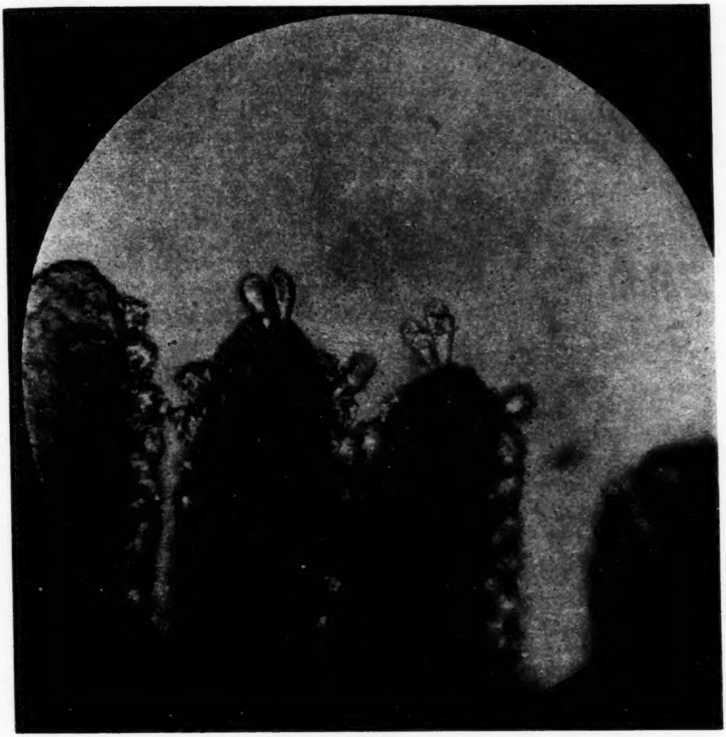

Figure 1. Living, but partly contracted, *Scyphidia micropteri* on gills of large-mouth black bass.

fined to the gill filaments, but it has been found distributed over the entire external surface of the fish, including the fins. It was found in the greatest abundance on the gill filaments. Figure 1 shows the parasites on the tips of gill filaments where they are most readily observed. Some idea of the quantitative abundance of the parasite may be obtained from the following data for largemouth black bass that survived the heavy mortality described previously. A 65-millimeter largemouth bass had twenty-seven, twenty-six, and thirty-five specimens, respectively, on each of three filaments; another largemouth bass 73 millimeters long had a total of 203 *Scyphidia* on the tips of forty filaments; individual counts for fifteen single filaments of the same fish showed an average of twenty-eight *Scyphidia* per filament. The maximum number per filament was fifty-one, the minimum seventeen.

## Description

Like many species of the genus, *Scyphidia micropteri* is urn-shaped (Figure 2). The average length of twenty-six living specimens selected at random was 58.6 microns (1/433 inch); the maximum length was 72.9 microns, the minimum length 45.7 microns. The average maximum width of the same group was 22.2 microns. The entire

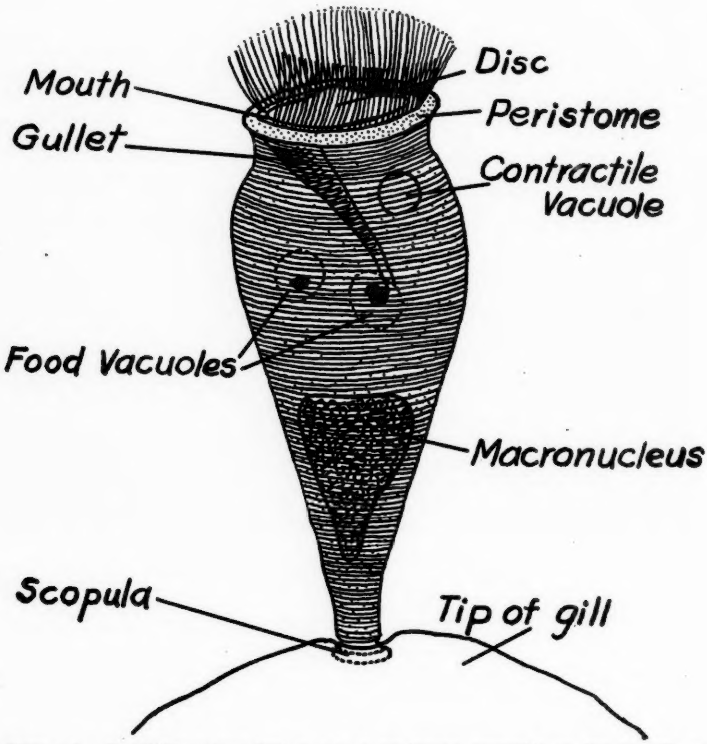


**Figure 2.** ***Scyphidia micropteri*, n. sp., a protozoan parasitic on largemouth and smallmouth black bass.**

body from base to peristome is annulated. In some specimens, and possibly all, there exists a thin, barely discernible ridge thicker than other annulations around the body immediately above the macronucleus. No band of central cilia has been found in this form. The attachment organ is a circular disc, the scopula, which measures about

7.0 microns in diameter. Superficially, the attachment organ appears to be buried in the epidermal cells of the gills and body, but microscopic studies of sectioned gill material showed that the scopula merely was attached to the surfaces of the irregular epidermal cells of low elevation.[2]

The inverted, cone-shaped macronucleus is very large and conspicuous even in unstained specimens, and it occupies the lower half of the body of the animal. The micronucleus appears rather definitely to be located in the slightly concave surface of the upper part of the macronucleus. In twelve specimens of the twenty-six studied in detail, the average distance from the anterior end of the body to the nucleus was 25.9 microns. Table 1 shows measurements in microns of eight large specimens preserved in formalin while Table 2 gives dimensions of twenty-six living organisms.

The peristome, when expanded, is nearly as wide as the body at its maximum width. In only a few instances did the diameter of the peristome exceed the maximum width of the same animal. Within the peristome is a double row of cilia approximately 16 to 20 microns in length. During the normal feeding of the organism, the cilia rotate rhythmically in a counter-clockwise direction toward the mouth. Cilia that beat more rapidly than those of the peristome are found inside of the rather long and deep gullet. *S. micropteri,* as well as other members of the genus, is highly contractile, and can be observed for only a brief time in an uncontracted condition unless the animal has been anesthetized with chloroform water, or some other anesthetic. Upon contracting, the peristome closes about the cilia, crowding them into the center of the anterior end of the body which assumes a conical form. When normal ciliary action ceases, the cilia sometimes group themselves into from eight to twelve clusters that resemble cirri. At times during contraction, the peristome disc assumes an almost pointed conical form.

The contractile vacuole is located rather high up in the anterior end of the body near the gullet and measures about 5.8 microns in diameter. Recurrent discharges from the contractile vacuole were observed in one specimen at intervals of thirteen seconds.

The body tapers gradually toward the scopula which has a width of about 7.0 microns. The terminal portions of the body and scopula are hidden among the irregular epidermal cells of the host. Immediately anterior to the scopula the body constricts rather abruptly to a very short stalk-like isthmus. *S. micropteri* is considered to be without a stalk because of the brevity of the isthmus and the fact that it is not ordinarily visible. It is probable that the isthmus is merely a part of the scopula which is a flat sucker-like disc.

---

[2]The writer is indebted to Dr. H. S. Davis for furnishing sectioned gills infested with large numbers of *Scyphidia micropteri.* Observations on the scopula were made from this material.

**TABLE 1. MEASUREMENTS, IN MICRONS, OF *SCYPHIDIA MICROPTERI* PRESERVED IN FORMALIN**

| Length | Maximum width | Distance of nucleus from anterior end | Length of macronucleus | Width of macronucleus | Diameter of scopula |
|---|---|---|---|---|---|
| 57.1 | 22.9 | 25.7 | 15.7 | 19.9 | ...... |
| 60.0 | 25.7 | 28.6 | 14.3 | 14.3 | 5.0 |
| 54.3 | 22.9 | 25.7 | 11.4 | 11.4 | ...... |
| 57.1 | 25.7 | 27.1 | 11.4 | 12.9 | 5.7 |
| 54.3 | 22.9 | 28.0 | 9.1 | 11.4 | 5.7 |
| 61.4 | 22.9 | 28.0 | 17.1 | 14.3 | 5.7 |
| 52.0 | 22.9 | 25.1 | 11.1 | 13.4 | ...... |
| 60.0 | 23.4 | 22.9 | 14.3 | 12.9 | 5.7 |
| | | **Averages** | | | |
| 57.0 | 23.7 | 26.4 | 13.1 | 13.8 | 5.6 |

**TABLE 2. MEASUREMENTS, IN MICRONS, OF LIVING *SCYPHIDIA MICROPTERI***

| Length | Maximum width | Diameter of expanded peristome | Length of nucleus | Width of nucleus | Diameter of base of animal | Diameter of contractile vacuole | Remarks |
|---|---|---|---|---|---|---|---|
| 62.9 | 25.7 | 24.3 | 16.4 | 15.0 | ...... | 5.7 | Uncontracted |
| 57.1 | 22.1 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 45.7 | 20.0 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 51.4 | 17.9 | ...... | ...... | ...... | ...... | 4.3 | Partly contracted |
| 45.7 | 20.0 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 62.9 | 24.3 | ...... | 14.3 | 13.7 | ...... | ...... | Partly contracted |
| 51.4 | 22.9 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 51.4 | 20.0 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 57.1 | 22.9 | ...... | ...... | ...... | 7.1 | ...... | Partly contracted |
| 58.6 | 22.9 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 51.4 | 20.0 | ...... | ...... | ...... | 10.0 | ...... | Partly contracted |
| 48.6 | 22.1 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 65.7 | 22.9 | ...... | 15.7 | 12.1 | ...... | 5.7 | Partly contracted |
| 60.0 | 22.9 | ...... | 15.7 | 11.4 | ...... | ...... | Uncontracted |
| 54.3 | 20.7 | ...... | 11.4 | 12.9 | ...... | ...... | Partly contracted |
| 62.9 | 18.6 | ...... | 20.0 | 11.4 | ...... | ...... | Partly contracted |
| 65.7 | 20.0 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 65.7 | 20.0 | ...... | 18.6 | 12.9 | ...... | ...... | Partly contracted |
| 62.9 | 27.1 | 25.7 | ...... | ...... | ...... | ...... | Peristome fully expanded |
| 65.7 | 25.7 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 57.1 | 20.0 | 22.9 | ...... | ...... | 7.1 | ...... | Peristome fully expanded |
| 51.4 | 22.9 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| 62.9 | 22.9 | 25.7 | ...... | ...... | ...... | ...... | Peristome expanded |
| 68.6 | 25.7 | ...... | 28.6 | 17.1 | ...... | ...... | Partly contracted |
| 62.9 | 20.0 | ...... | 15.7 | 12.9 | ...... | 6.4 | Partly contracted |
| 72.9 | 27.1 | ...... | ...... | ...... | ...... | ...... | Partly contracted |
| | | | **Averages** | | | | |
| 58.6 | 22.2 | 24.7 | 17.4 | 13.3 | 8.1 | 5.5 | ...... |

Longitudinal fission is the only method of reproduction which has been observed. Only the late stages in the division of three individuals into six new individuals were observed. In all instances, when first observed, the macronuclei were already largely divided and were connected by narrow isthmi of nuclear material. The rounded masses of nuclear material of the macronuclei were near the centers of the already largely separated halves, and, at this stage, the cilia and other structural elements about the peristome were undifferentiated. In two of the three individuals, whose reproduction was studied, separation of the halves occurred rather quickly. Death of all of the resultant individuals made further observation impossible. The parasite was observed over a considerable period, from August 21 to December 15, 1938, when abundant material for observation was available.

Two experimental lots of largemouth fingerlings treated August 27, with 3 per cent salt solution and 1:500 glacial acetic acid, respectively, were nearly free of parasites on August 30, but some specimens of the parasite survived a single application of both methods of treatment.

## Literature Cited

Grenfell, J. G.
1887. XI—On new species of Scyphidia and Dinophysis. Journal of the Royal Microscopical Society. Pp. 558-560. London.

Kahl, A.
1935. Urtiere oder Protozoa I. Wimpertiere oder Ciliata (Infusoria) 4. Peritricha und Chonotricha. Die Tierwelt Deutschlands. 30 Teil, S. 651-886, mit 1,053 Abbildungen im text.

Roux, Jean
1901. Faune Infusorienne des eaux stagnantes des environs de Genève, 149 pp., 8 pl., 4 to., Genève.

# PRELIMINARY OBSERVATIONS ON THE EGG-EATING HABITS OF THE ROSYSIDE SUCKER

JAMES C. SIMPSON

*Wyoming Game and Fish Commission, Cheyenne*

It is a common belief among fishermen who fish Jackson Lake, Wyoming, that the lake-trout angling of this lake eventually will be ruined as the result of the egg-eating habits of the rosyside sucker, *Catostomus fecundus* Cope and Yarrow, which is abundant in the lake. Since no authentic information had been gathered previously which incriminated the sucker as an egg eater, a field party from the Wyoming Game and Fish Department was instructed to gather such information as it could on the egg-eating habits of the rosyside sucker during the spawning season of the lake trout of Jackson Lake. The data on which this paper is based were obtained during the fall of 1938.

The Wyoming field party worked in cooperation with a crew of U. S. Bureau of Fisheries spawn collectors who were engaged in an attempt to collect eggs from the lake trout, *Cristivomer namaycush* (Walbaum).

Jackson Lake supports a variety of fishes, some of which may be considered as potential egg eaters. In addition to lake trout, the following game fishes are present: Cutthroat trout, rainbow trout, brown trout, Montana grayling, and Rocky Mountain whitefish. The silver side minnow, dusky dace, Utah Lake chub, and blob represent the forage fishes, other than the rosyside sucker, which are found in the lake.

Twenty-one suckers were collected from three lake trout spawning beds. The suckers were taken with gill nets at depths that ranged from 6 to 20 feet. Nets were raised at two-hour intervals and the fish removed. Nine of the suckers were known definitely to have eaten lake trout eggs in numbers that ranged from 5 to 150, as was evidenced by the presence of whole eggs or egg shells in the stomachs. The presence of yellow pigment in the intestines of two other suckers indicated, but not conclusively, that they may also have eaten eggs. Trap-net sets on other shoals where lake trout were not caught and where there was no indication of lake trout spawning did not yield any suckers with eggs in their stomachs. Forty-five suckers taken in this manner showed no evidence of having eaten eggs. The shoal from which these suckers were taken differed from the spawning shoals of the lake trout in one respect only: it arose from deep water by long, sloping approaches rather than abruptly from the deep water as the spawning shoals did.

The date, sex, standard length, weight, method, depth and place of capture were all recorded for each fish. No attempt was made to determine the kinds of food available for suckers in the lake, nor have

any investigations been made of the food eaten by the rosyside sucker other than trout eggs. Apparently the larger suckers preyed more extensively on the lake trout eggs than did the smaller suckers. A future project will include a study of the food of the lake trout of Jackson Lake. The young of the rosyside sucker has been reported by fishermen to be a common item of food for the lake trout but the extent to which it is used is yet unknown. The value of the sucker as a forage fish must be balanced against its negative value as an egg predator before definite steps should be taken toward its control. If it is found advisable to control the rosyside sucker, the necessary procedure will be greatly facilitated by the fact that the sucker runs by the thousands into the tributaries of Jackson Lake each spring in order to spawn.

Catches of lake trout in Jackson Lake continue to be large even though the average size of the individuals becomes smaller each year. This smaller size seems to indicate that the lake is overfished. The supply of lake trout in Jackson Lake has been sustained almost entirely through natural reproduction. The number of fishermen is increasing each year.

## Conclusions

The stomachs of about 40 per cent of the rosyside suckers taken from lake trout spawning beds in Jackson Lake contained lake trout eggs. About 10 per cent were thought to have eaten eggs, and 50 per cent showed no traces of eggs in the stomachs. None of the suckers taken from shoals where lake trout were not spawning contained eggs in their stomachs.

# QUANTITATIVE AND QUALITATIVE OBSERVATIONS ON FISH FOODS IN WADDELL CREEK LAGOON[1]

P. R. NEEDHAM

*U. S. Bureau of Fisheries, Stanford University, California*

## ABSTRACT

Seasonal studies of bottom foods were made in Waddell Creek Lagoon in 1932, 1933, and 1934. Quantitative samples were taken both with an Ekman dredge and a square-foot box. The numbers of organisms per square meter and pounds of food per acre are based on recalculations of results obtained from the unit areas sampled.

The most abundant bottom populations by weight were found in March, and the least in November. Dominant animals were three crustaceans: two amphipods, *Gammarus confervicolis* and *Corophium spinicorne*, and one isopod, *Exosphaeroma oregonensis*. These are brackish water forms and almost completely replace typical fresh-water forms in the inter-tidal areas in Waddell Lagoon. Steelhead trout were found to eat large numbers of *Gammarus*, considerably less of *Exosphaeroma*, while no *Corophium* were found in the stomachs examined. A summary of results is given at the end of the paper.

## DESCRIPTION OF WADDELL CREEK

The food studies herein reported were undertaken as a regular part of the program of the California Trout Investigations from 1932 to 1934. Detailed studies of the life history and habits of coastal-stream steelhead trout and silver salmon had been conducted in Waddell Creek, Santa Cruz County, California, since 1932. General observations suggested that lagoons of coastal streams served as good natural rearing ponds for young steelhead trout and silver salmon prior to their migrations into salt water. In fact, lagoons of coastal streams were considered to furnish such excellent nursery and feeding grounds for young trout and salmon that in 1932 the California Division of Fish and Game closed certain lagoons to angling in the summer months to afford greater protection to seaward migrants. More detailed observations seemed desirable to determine the seasonal availability of each major lagoon food, the contribution of each food item by weight compared to numbers of individuals, and the contribution of the various organisms to the diet of trout.[2] A two-way fish counting weir was constructed across Waddell Creek in 1933 about 1.5 miles above its mouth and well above the upper limits of tidewater. The weir furnished the means of counting all upstream migrants and a proportion of downstream migrating salmon and trout. References made in this

[1]published with permission of the Commissioner of Fisheries.

[2]The help of Mr. Francis Sumner, Mr. Elden H. Vestal, and of Mr. Leo Shapovalov in this work is gratefully acknowledged. Thanks are also given to the California Division of Fish and Game and to Emeritus Dean of Engineering, Professor Theodore Hoover of Stanford University, who supplied excellent field laboratory and living quarters on Waddell Creek; to Stanford University for laboratory and library facilities furnished on the Stanford Campus. The help of W.P.A. Project No. 10,533 is also acknowledged.

paper to the movements of those fishes are based on observations made at this weir which was described by Taft (1934 and 1936).

From its upper reaches in the Santa Cruz Mountains, Waddell Creek flows about 15 miles southwest into the Pacific Ocean at a point 22 miles north of Santa Cruz, California. Like other coastal streams, Waddell Creek is subject to extreme seasonal fluctuations. In the dry season of early fall the flow may diminish to as low as 200 gallons per minute (0.45 cubic feet per second), while during the rainy season in late winter and early spring a flow of 224,400 gallons per minute (500 cubic feet per second) is not unusual. The interaction of stream flow, ocean tides, and storms have produced a sandy beach, or bar, which extends for over 3,000 feet across the mouth of the creek where it enters the ocean.

Lagoons offer a highly unstable environment for fish-food organisms. High tide, or waves during storms, may raise the height of the sand bar across the outlet, thereby increasing the depth and size of the lagoon by impounding more water. Conversely, floods often cut down the height of the bar at the ocean so that the normally quiet water of the lagoon is replaced by a swiftly flowing stream. Swift water does but little harm to lagoon populations in the wider, broader lagoon areas. In narrow places, however, washing occurs, and collections taken in such places contained but few animals.

The point of entrance of the water into the ocean often changes. The water usually enters the ocean at the south end of the bar. In a single season, depending upon conditions, it may break through the bar at several different points, each being closed in turn by wave or tidal action. Floods pouring into the lagoon from the stream above usually make the initial break in the bar. The mouth of the lagoon usually does not remain closed more than three or four weeks at a time.

High tides may reverse the normal direction of flow. Thus, aquatic conditions in the lagoon will vary seasonally from pure fresh-water through typical brackish-water lagoon conditions, to nearly pure sea-water conditions. Lagoons contain rather amazing amounts of food when these hazardous life conditions are considered.

The bottom of the lagoon is composed mostly of sand. Some gravel usually is present, as are scattered masses of vegetable and animal debris dropped out by flood waters. Superficially, lagoon bottoms have a barren appearance but this impression is soon dispelled by sampling.

## Lagoon Temperatures and Fauna

Fifteen air-temperature readings taken in March and April, 1934, during the course of the bottom sampling operations averaged 57.2°F. Minimum and maximum temperatures were 45°F. to 61.5°F., respectively. Fifteen water-temperature readings, taken at the same time, average 57.5°F. and they ranged between 52°F. minimum and 61.2°F. maximum. On June 30, 1933, a temperature of 74.5°F. was recorded

in the stagnant, algae-filled, lower end of the lagoon during a period of low stream run-off and hot weather. Percolation of water through the sand bar, coupled with pumping water out for irrigation, often prevents any direct surface flow into the ocean.

The number and species of fishes found in the lagoon depend upon water conditions and season. Both steelhead (*Salmo gairdnerii*) and silver salmon (*Oncorhynchus kisutch*) pass through the lagoon during their fall, winter, and spring migrations upstream to spawn. Later, adult steelhead and the young of both steelhead and silver salmon migrate downstream to the lagoon where they may remain for some time before entering the ocean. From counts of migrants made at the weir, it is known that some steelhead at least, return upstream without having gone into the ocean. This is one fact which makes closer investigation of the food capacity of California coastal lagoons more desirable. Varying numbers of the common stickleback, (*Gasterosteus aculeatus*), gobies (*Eucylogobius newberryi*), sculpins (*Cottus asper*), and striped bass (*Roccus lineatus*) occur in the lagoon. The starry flounder (*Platichthys stellatus*), the smooth cabezone (*Leptocottus armatus*), and possibly a few others, are found among the transient flat fishes and cottoids present. Carl (1937) reported *Gasterosteus aculeatus, Cottus asper,* and *Platichthys stellatus* from Lost Lagoon on Vancouver Island in similar brackish-water conditions.

The dominant bottom food organisms found in the lagoon are two amphipods and one isopod crustacean: namely, *Gammarus confervicolis, Corophium spinicorne,* and *Exosphaeroma oregonensis,* important and abundant in the order named. Carl (op. cit.) reported that both *Gammarus and Exosphaeroma* were common, but that *Corophium* was scarce, in Lost Lagoon on Vancouver Island, B. C. Other organisms which are listed as miscellaneous in the tables, included ostracod and copepod crustaceans, insects (mainly midge larvae and pupae), hydrachnids, molluscs, and oligochaetes. Ciliate protozoans were identified which belonged to the genera *Spirostomus, Euplotes, Pleuronema, Colpidium, Prorodon,* and *Oxytricha.*[3]

No detailed study of the plankton of Waddell Lagoon was undertaken, but an occasional haul was made with a No. 20 bolting-silk net. Copepods, both adults and nauplii, usually were abundant. Plankton algae, with rotifers and protozoans, were also abundant particularly during the summer when the mouth of the lagoon was closed. The mysid, *Neomysis mercedis,* was the largest form taken in the plankton and was often seen darting about in the water.

## METHODS

Most of the bottom samples were obtained with an Ekman dredge which takes samples from an area of 0.25 square foot. Some of the samples were taken with the galvanized, square-foot sampler devised

[3]The writer is indebted to Dr. Laura Garnjobst, Instructor in Protozoology at Stanford University, for this information obtained July 20, 1937.

by Needham (1927). Wet weights of organisms were obtained after removing surplus moisture with blotting paper for one minute after the living organisms had been picked from trash taken with the samples.

In order to obtain information on the consumption of food organisms by trout in the lagoon, 100 yearling steelhead were confined in a cage (dimensions: 3 by 3 by 4 feet) in the center of the lagoon. The size of the wire cloth used for the cage permitted bottom animals to enter but was small enough to prevent the escape of the trout. In addition, sand from the lagoon was dumped into the cage to provide the natural type of bottom. While it may be questionable whether or not trout so held could obtain a fair sample of lagoon foods, it is believed that such procedure would give a fair idea of the food selectivity of the fish. Stomach examinations of the imprisoned fish made possible a comparison of foods actually eaten with those taken in the bottom samples. However, because the conditions were not natural, stomach examinations of wild trout from the lagoon might give somewhat different results.

## Seasonal Availability[4] of Lagoon Foods

A total of forty-three bottom samples, taken in six different months in Waddell Lagoon revealed significant variations in the seasonal abundance of foods (Table 1). The peak as to numbers of organisms occurred in the five samples taken in February which averaged 14,241 organisms per square meter. Fourteen samples taken in May averaged only 8,177 organisms per square meter, the lowest average obtained. The average per square meter for the months during which bottom samples were taken was 10,049. This average is substantially higher than that (6,503) obtained for the same unit area in fresh-water riffles of Waddell Creek above the lagoon (Needham, 1934).

**TABLE 1. SEASONAL AVAILABILITY OF BOTTOM FOODS IN WADDELL CREEK LAGOON**

| Dates | Number of samples taken | Average number of organisms per square meter | Wet weight of food in grams per square foot | Pounds of food per acre | Average number of shrimp per square meter |
|---|---|---|---|---|---|
| Nov. 29, 30, 1932 | 9 | 8,667 | 1.26 | 121 | 5,179 |
| Jan. 11, 12, 1933 | 3 | 13,762 | 3.69 | 354 | 9,579 |
| Feb. 20, 21, 1933 | 5 | 14,241 | 3.43 | 329 | 10,658 |
| Mar. 22, 23, 1934 | 7 | 10,587 | 4.54 | 436 | 5,054 |
| April 5, 1933, and April 4, 5, 6, 1934 | 13 | 9,114 | 2.58 | 247 | 5,247 |
| May 15, 16, 1933 | 6 | 8,177 | 3.00 | 288 | 516 |
| Totals and averages | 43 | 10,049 | 2.86 | 274 | 4,884 |

[4]The term "available" or "availability" is used here to mean potential, rather than actual, availability. An animal may be abundant as to numbers and its potential value as a food be high, but if trout cannot get them to eat because of its habits, or for other reasons, its actual availability as a food element may be very low. This is true of the tube-dwelling amphipod *Corophium* discussed in this paper.

In terms of pounds of food per acre, the highest poundage occurred in March which gave a calculated standing crop of 436 pounds per acre. The lowest occurred in November at 121 pounds per acre. The average for the months covered was 274 pounds per acre. This is 78 pounds per acre higher than the average found in riffles of Waddell Creek above the lagoon as reported by Needham (op. cit.) which was 196 pounds per acre, computed from seventy-six bottom samples taken in 1932 and 1933.

In Table 1 it will be noted that there is apparent lack of correlation between numbers of organisms per square meter and pounds of food per acre. For example, the May series of samples gave a calculated average of 8,177 organisms per square meter and 288 pounds of food per acre, while the November series gave an estimated number of 8,667 organisms per square meter and a computed standing crop of only 121 pounds per acre. The apparent lack of correlation can be explained by the differences in the body weights of the animals taken in each series of samples. Scuds or "shrimp" in the samples varied considerably in size. Sometimes mainly large, relatively heavy, full-grown specimens would be taken while other samples would contain mostly small, immature, recently hatched forms. The same was true of the other animals collected though to a lesser extent.

## Weight Compared with Numbers of Food Organisms

The percentage contribution of each major lagoon organism both as to numbers and weight of foods is presented in Table 2. The data were obtained by weighing separately the three major elements, *Gammarus, Corophium,* and *Exosphaeroma,* in each of a series of eight bottom samples taken in March and April, 1934.

**TABLE 2. PRINCIPAL ORGANISMS BY WEIGHT AND NUMBER IN WADDELL LAGOON[1]**

| Organism | Total number | Per cent by number | Total weight | Per cent by weight |
|---|---|---|---|---|
| *Gammarus* | 4,492 | 59.2 | 7.328 | 40.0 |
| *Corophium* | 2,480 | 32.7 | 6.372 | 34.7 |
| *Exosphaeroma* | 440 | 5.8 | 1.981 | 10.8 |
| Miscellaneous | 176 | 2.3 | 2.660 | 14.5 |
| Totals | 7,588 | ..... | 18.341 | ...... |

[1]Based on eight samples taken with an Ekman Dredge March 23 and April 4-6, 1934, computed on 1 square foot.

Scuds, *Gammarus,* contributed the most common single food item and the amphipod, *Corophium,* formed the second most abundant food. However, as shown in Table 4, no *Corophium* are eaten by trout, probably because of their secretive habits which make them difficult for the trout to find. *Exosphaeroma* which contributed only about 6 per cent of the total foods as to number, and over 10 per cent by weight, was second in importance as food of the trout.

In Table 1 it will be noted that two series of samples taken in April in 1933 and 1934 were combined into one category. This seemed desirable since both series were taken at about the same time of the year. The natural variation in abundance of foods found in the same month in two different years is presented in Table 3.

The April, 1933, series gave the higher calculated value of 313 pounds of food per acre, while the 1934 series gave an estimate of only 191 pounds per acre. With reference to both total number of organisms and numbers calculated per square meter, the 1934 samples were higher in spite of the fact that the calculated pounds of food per acre was 122 pounds less than in the 1933 samples. Here again the apparent

**TABLE 3. FOODS FOUND IN TWO SERIES OF SAMPLES TAKEN IN APRIL, 1933 AND 1934**[1]

| Organism | April 5, 1933 Number | Per cent | April 4, 5, 6, 1934 Number | Per cent |
|---|---|---|---|---|
| *Gammarus confervicolis* | 2,336 | 50.0 | 4,004 | 63.1 |
| *Corophium spinicorne* | 1,880 | 40.3 | 1,844 | 29.0 |
| *Exosphaeroma oregonensis* | 372 | 7.9 | 408 | 6.4 |
| Miscellaneous | 80 | 1.7 | 88 | 1.4 |
| Totals | 4,668 | ...... | 6,344 | ...... |

[1]Data computed from Ekman dredge samples (0.25 square foot) to 1 square foot.

lack of correlation between numbers and weight was due to the fact that organisms taken in the 1934 series, while more abundant, were smaller and more immature forms. Further evidence is shown by the fact that a total of 6,344 animals taken in the seven 1934 samples averaged only 1.99 grams per square foot whereas the 1933 series produced a total of 4,668 animals at an average weight of 3.26 grams per square foot.

## Foods Available Compared to Foods Eaten by Trout

In order to compare available foods with those consumed by trout, all organisms collected were tabulated with the foods found in the stomachs of fourteen yearling steelhead trout retained in the experimental cage in the lagoon (Table 4).

**TABLE 4. COMPARISON OF AVAILABLE WITH CONSUMED FOODS IN WADDELL CREEK LAGOON**

| Organism | Available foods[1] Number | Per cent | Consumed foods[2] Number | Per cent |
|---|---|---|---|---|
| *Gammarus confervicolis* | 21,872 | 54.45 | 122 | 93.84 |
| *Corophium spinicorne* | 14,151 | 35.23 | 0 | 0.00 |
| *Exosphaeroma oregonensis* | 1,955 | 4.87 | 5 | 3.84 |
| Miscellaneous | 2,187 | 5.44 | 3 | 2.31 |
| Totals | 40,165 | ........ | 130 | ........ |

[1]Based on numbers taken in forty-three lagoon bottom samples listed in Table 1.

[2]Based on stomach examinations of fourteen yearling steelhead trout held in a cage in the middle of the lagoon. The average size of those examined was 3.4 inches and they ranged between 2.8 and 4.7 inches. Those examined for stomach contents were taken between March 1 and March 10, 1933.

The scud, *G. confervicolis,* was of prime importance both as to its availability as a food and its actual consumption by trout. This animal formed over 54 per cent of the available lagoon foods and over 93 per cent of the foods eaten by the trout. Its non-secretive, scavenging habits, freedom of movement over the bottom, and adaptability to the widely fluctuating lagoon conditions, serve in part to explain its dominant position among lagoon organisms.

The amphipod, *C. spinicorne,* in contrast to *G. confervicolis,* has much more secretive and restricted habits since it lives mainly in tubes in the bottom sand. While *Corophium* formed over 35 per cent of the available lagoon foods not a single specimen was found in the stomachs examined. Bradley (1908) showed that a closely related species, *C. salmonis,* was consumed in considerable quantities by young sockeye, silver, and king salmon taken by the U. S. Bureau of Fisheries investigators at Karluk Beach and in the estuary of Karluk River in Alaska. The fish ranged from 71 to 145 millimeters in length. The type specimen of *C. salmonis* was taken from the stomach of a salmon caught in Puget Sound. Shapovalov (1936) reported on foods eaten by forty-seven striped bass (*Roccus lineatus*), netted from Waddell Creek Lagoon in April, 1935, and showed that twenty-four of the smaller bass had eaten *Gammarus,* seven had consumed *Corophium,* and five had eaten the isopod, *Exosphaeroma.* The fish ranged between 20 and 49 centimeters in length.

The isopod, *E. oregonensis,* in contrast to the scud, *Gammarus,* was relatively scarce in the bottom samples. It formed only about 5 per cent of the total available foods and less than 3 per cent of the foods eaten by the trout.

The miscellaneous foods listed in Table 4 comprised approximately 5 per cent of the foods available to fishes in the lagoon and made up about 3 per cent of those consumed by trout.[5]

It is of interest to note that the tube-dweller, *Corophium,* is not restricted to the bottom areas covered with water. One can often see the tiny tubes protruding from the sand by the hundreds along the damp, sandy shore of the lagoon close to the edge of the water. A square-foot sample was taken at such a place some 14 inches from the edge of the water, and 332 live *Corophium* were found that had a wet weight of 0.59 gram. Evidently these animals are well adapted to fluctuating lagoon levels.

## Foods of Upper Tidewater Limits

The limit of the upper end of the lagoon naturally varies with the

---

[5]The yearling steelhead trout held in the experimental cage in the lagoon grew a total of 0.93 inches in ninety-one days between February 28 and May 30, 1933. When transferred to the cage from the hatchery the fish were quite dark in color. A little over a month later some had turned definitely silvery in color, while others showed a bright pink stripe on their sides, characteristic of rainbow trout. All were fat and in splendid condition. The fish were subject to all the vicissitudes of high tides, floods, and changing salinities in the cage during the period they were confined.

height of water in the lagoon. When the mouth is closed by the sand bar, water is impounded and the level may rise as much as 3 feet. Bottom samples taken seasonally from a single station near the upper limits of brackish water show interesting fluctuations both as to amounts and kinds of foods obtained from time to time.

On January 11, 1933, when the first sample was taken (Table 5),

**TABLE 5. KINDS AND AMOUNTS OF FOOD FROM THE SAME AREA OF WADDELL CREEK IN THE UPPER TIDAL WATER LIMITS AT DIFFERENT TIMES OF YEAR**[1]

| Date | Weight of animals per square foot | Number of organisms per square foot | | |
|---|---|---|---|---|
| | | Brackish water organisms | | Fresh-water insect larvae and nymphs |
| | | Scuds (*Gammarus*) | Isopods (*Exosphaeroma*) | |
| January 11, 1933. Lagoon conditions brackish-water | 7.01 | 1,827 | 147 | 3 |
| February 16, 1933. Fresh-water conditions | 0.62 | 28 | 0 | 144 |
| April 3, 1933. Fresh-water conditions | 0.38 | 3 | 6 | 111 |
| May 16, 1933. Fresh-water conditions | 2.69 | 8 | 80 | 622 |

[1]Based on data from bottom samples taken in same riffle area 300 yards above the second road bridge over Waddell Creek.

the water was high in the lagoon and brackish-water conditions prevailed. There was practically no current on the riffle where the sample was obtained. The dominant animals collected were 1,827 scuds, *Gammarus,* and 147 isopods, along with only two fresh-water forms, and only a single specimen of *C. spinicorne.* About a month later, on February 16, the lagoon had opened and the previously quiet water over the riffle was replaced by shallow, swift water. Then the number of *Gammarus* found was only twenty-eight, no *Exosphaeroma* or *Corophium* were taken, and the number of fresh-water forms had increased to 144, most of which were mayfly nymphs and the aquatic Diptera larvae, *Simulium.*

In subsequent samples taken on April 3 and May 16 the numbers of *Gammarus* collected remained between three and eight specimens only; *Exosphaeroma* increased to a total of eighty (May 16) and the number of typical fresh-water forms increased greatly. Strictly fresh-water conditions prevailed when the samples of February 16, April 3, and May 16 were taken. It is evident, then, that both *E. oregonensis* and *G. confervicolis* can stand pure fresh water for a considerable period. As shown in Table 5, *G. confervicolis,* by reason of the rapid decline in numbers found following intrusion of fresh water over the riffle, is less adaptable than *E. oregonensis* in this regard. Numbers of the latter actually increased following fresh-water conditions. Carl (1937) noted that both *E. oregonensis* and *G. confervicolis* are found occasionally in fresh water.

## Summary

1. A quantitative study of bottom foods in Waddell Creek Lagoon gave a calculated average annual standing crop of 274 pounds per acre based on six seasonal series of samples.

2. Samples taken in March gave the highest calculated poundage per acre (436), while those collected in November gave the lowest (121 pounds per acre).

3. Crustaceans were the dominant food organisms. These were *Gammarus confervicolis, Corophium spinicorne,* and *Exosphaeroma oregonensis*. This order of priority also existed with regard to the contribution of each by weight, as well as by numbers to lagoon populations.

4. High numbers of organisms per square meter was not necessarily correlated with high poundage per acre.

5. Yearly variation in amounts of food found in the same month was indicated by comparison of two series of samples taken in April, 1933, and April, 1934.

6. *G. confervicolis* formed over 93 per cent, by number, of the food of steelhead trout; *E. oregonensis,* about 4 per cent; while no *C. spinicorne* whatsoever were found in the stomachs examined. Miscellaneous items made up about 3 per cent.

7. The brackish-water animals, *G. confervicolis* and *E. oregonensis* can stand pure fresh water, but the latter form apparently is more adaptable than the former in this regard.

## Literature Cited

Bradley, J. C.
1908. Notes on two amphipods of the Genus *Corophium* from the Pacific Coast. Univ. Calif. Publ. Zoology, Vol. 4, No. 4, pp. 227-252.

Carl, G. Clifford.
1937. Flora and fauna of brackish water. Ecology, Vol. 18, No. 3, pp. 446-453.

Needham, P. R.
1927. A quantitative study of the fish food supply in selected areas. In: A biological survey of the Oswego River system, N. Y. Cons. Dept., Supp. 17th Ann. Rept., pp. 192-206.
1934. Quantitative studies of stream bottom foods. Trans. Amer. Fish. Soc., Vol. 64, pp. 238-247.

Shapovalov, Leo.
1936. Food of striped bass. Calif. Fish and Game, Vol. 22, No. 4, pp. 261-271.

Taft, A. C.
1934. California steelhead experiments. Trans. Amer. Fish. Soc., Vol. 64, pp. 248-251.
1936. The Waddell Creek experimental station for trout and salmon studies. Calif. Fish and Game, Vol. 22, No. 2, pp. 99-104.

# THE PRODUCTION OF RAINBOW TROUT AT PAUL LAKE, BRITISH COLUMBIA

C. McC. Mottley

*Cornell University, Ithaca, New York*

## Abstract

Three of the major problems connected with rainbow trout production and management were studied at Paul Lake, British Columbia: (1) what quantity of fish can be produced in a given body of water, (2) how big a crop can be removed and still allow a sustained yield, (3) how great a financial expenditure to increase production may be justified. The investigation covered a period from 1931 through 1936 in which a consistent stocking policy requiring the planting of 200,000 one-inch fry was carried out. The data show that the lake was capable of producing about 10 pounds of trout per acre and that this amount is being maintained under the policy outlined. The mortality amounted to about 95 per cent, providing a 5 per cent yield to the fishermen. The cost of the stocking operations was judged to be commensurate with the return to the people of the Kamloops District. It is suggested that intensive management of this type should be instituted only after adequate surveys have been made of individual bodies of water.

---

In 1931 the writer began a study of the rainbow trout population in Paul Lake near Kamloops, British Columbia, primarily for the purpose of developing a satisfactory management policy for the lake, and secondarily to obtain data on three production problems: (1) what quantity of fish can be produced in suitable water; (2) what quantity of fish can be removed from year to year as a crop and still allow a sustained yield; and (3) how great a financial expenditure to increase production may be justified. The findings of the preliminary study made in 1931 have been published (Mottley, 1932). Subsequent papers (Rawson, 1934; Mottley, 1937a, 1937b, 1938; Mottley and Mottley, 1932) dealt with various phases of the investigation. Yearly summary reports of the findings have been issued by the Fisheries Research Board of Canada (Annual Report, Biological Board of Canada, 1931 to 1936) but no attempt has been made to bring the production data together. It seemed advisable to consolidate the data because of the wide interest being shown in matters related to fisheries management.

Paul Lake was selected for the study because it possessed certain natural advantages for a scientific investigation. It is situated in the "dry-belt" of the hinterland of the Pacific slope and is typical of hundreds of lakes in the interior of British Columbia and the States of the Northwest. The lake is about 3½ miles long and ½ mile wide; its surface covers 1,000 acres and it has an average depth of 100 feet. The outlet is screened to prevent the fish from getting into irrigation

ditches, and there is only one important tributary entering the lake into which the fish migrate during the spring for spawning.

The lake originally contained no fish of any kind owing to the presence of high falls below the outlet which prevented natural immigration. It was richly supplied, however, with organisms such as *Gammarus, Hyalella, Physa, Limnaea,* leeches and aquatic insects upon which the trout could feed. The Dominion Department of Fisheries stocked the lake in 1909 with rainbow trout obtained from a natural population in Adams Lake nearby. This trout was described by Jordan as *Salmo kamloops,* a name that has been reduced to synonymy with *Salmo gairdnerii* through studies of the taxonomic characters on which the separation was based (Mottley 1934, 1936a, 1936b). From the original planting, recorded as 5,000 free-swimming fry, the stock grew and multiplied to such an extent that the Fisheries Department was able to establish an egg-collecting station and a hatchery in the vicinity in 1922. The eggs and fry of this popular variety of trout were used to stock other bodies of water. Meanwhile a fishing lodge was built, a good motor road was opened up, and people came from the surrounding district and all parts of the world to enjoy the excellent fishing. Owing to the heavy drain caused by the sportsmen and the great demand for the eggs, depletion began to appear. The decline became serious in 1930 after two extremely dry years had reduced the flow of water in the tributary stream and thereby curtailed the natural production of fry. The six points that provide evidence of depletion were described in the preliminary paper (Mottley, 1932).

Up to the time the study was started no one had determined how many fish should be planted in a lake, particularly one where hatchery operations were being carried on, together with a heavy drain by the sportsmen. One of the first problems, therefore, was to lay down a consistent stocking policy. Embody (1927) outlined a stocking policy for streams and his method was drawn upon in determining the size of the planting to be made in Paul Lake. The biological survey (Rawson, 1934) showed that the shore zone was rich in food organisms, and it was assumed that the potential feeding ground around the lake was equal to the best grade of stream about thirty feet wide. The total distance, 7 miles, was then used to compute a total planting of 200,000 one-inch fry. The fish were planted around the shore of the lake as the fry reached the free-swimming stage. It was decided to continue this planting annually for several years and to make studies of the catch and the spawning escapement to determine the results of the plantings.

The total number of fish caught, the average weight, the total weight computed from this average, the number of boat-days, the average number of fish caught per boat-day, and the number of fish in the spawning run are shown in Table 1. The method of arriving at the estimates is set forth in the various summary reports in the Annual Report of the Biological Board of Canada.

The table shows that the total number of fish caught by the anglers increased gradually under the stocking policy which was adopted; the total weight likewise increased but, although the number caught was trebled, the weight was only doubled. An important feature is the decrease in average weight from 1.5 pounds to approximately 1 pound.

**TABLE 1. PRODUCTION DATA FOR A FIVE-YEAR PERIOD AT PAUL LAKE, BRITISH COLUMBIA**

| Year | Total number of fish caught | Average weight (pounds) | Total weight of fish caught (pounds) | Number of boat-days | Average number of fish per boat-day | Number of fish in spawning run |
|---|---|---|---|---|---|---|
| 1932 | 3,000 | 1.49 | 4,500 | 750 | 4 | 500 |
| 1933 | 6,000 | 1.53 | 9,200 | 1,000 | 6 | 850 |
| 1934 | 8,000 | 1.17 | 9,300 | 1,000 | 8 | 1,500 |
| 1935 | 12,000 | 0.94 | 11,300 | 1,200 | 10 | 2,300 |
| 1936 | 10,000 | 1.00 | 10,000 | 1,100 | 9 | 2,500 |

The fishing effort is measured by the number of boat-days, which represents to a certain extent the attractiveness of the fishery and at the same time reflects the economic return to those people who cater to the anglers. The total number of boat-days increased in 1933, correlated with the increase in the total number of fish caught. The general condition of a fishery can be measured by the yield per unit of fishing effort and this is shown as the average number of fish per boat-day. There is a very close correspondence between the yield per unit of effort and the total number caught. The number of fish in the spawning run likewise increased under the stocking policy; the number at the end of the five-year period was five times as great as at the start.

Reports from the fishery for 1937 and 1938 indicate that the total catch is remaining at a fairly steady level of between 9,000 and 10,000 fish per year.

If the foregoing data are representative, and it seems likely that they are, then it is possible to give a definite answer to the major problems stated above. The average crop for Paul Lake is approximately 10 pounds per acre and this figure may be taken as a measure of the lake's productivity. As long as an annual planting of 200,000 fry is made the lake probably will continue to produce this amount unless there is some cyclic fluctuation in the food supply or the factors affecting the mortality of the trout. The mortality of the trout arises from two sources: sport fishing and "natural causes." Out of the total planting only about 5 per cent reached the fishermen's creels. This survival rate checks rather closely with that on which Embody's (1927) stocking policy was based. Studies showed that the greatest part of the mortality occurred in the first year and was due chiefly to

the yearlings eating the fry and fingerlings. However, the success of the whole program depends on the fact that cannibalism controls, to a certain extent, the number of fish that reach legal size. If too many survive there is a distinct danger of depleting the food supply.

The data also provide information on the question of how big a crop can be removed without interfering with the breeding stock. Scale studies, as yet unreported, showed that the male Kamloop trout mature for the first time at from one to six years, the majority at three years of age; the females mature for the first time at from two to six years, the majority at three or four years of age. It is evident that while the fishermen are thinning out the stock they may also catch a large number of maturing and mature fish, but where production is controlled this is really not a very serious matter. It so happens that the ratio between the total number of fish caught at Paul Lake and the number that escaped to spawn each year averaged about 5:1. This ratio undoubtedly depends on such things as the intensity of the fishing, the depth of the lake and the nature of the food supply, and it would be expected, therefore, to fluctuate from year to year and from one body of water to another.

The average number of fish in the spawning run was about 1,500. Owing to the fact that a large number of males matured at two years of age, there were a few more males than females in the run; the average was about 600 females. The mature females carried about 2,500 eggs, or roughly 1,000 eggs per pound, but all of the eggs were not collectible owing to certain technical difficulties in ripening and stripping the fish; a collection of one million eggs was an average yield from the run. If 200,000 fry are required to keep up the stock there remains a clear gain of at least 700,000 fry after making due allowances for normal mortality in the hatchery. This surplus can be used to build up depleted stocks elsewhere. A preliminary study has shown that if the seeding were left entirely to nature it might require practically all of the fry produced by the run to keep up the stock.

In this type of lake where a definite annual seeding is always assured, very heavy fishing can be allowed. The breeding stock could be cut down to four or five hundred head without endangering the future supply of young. The chief danger lies in the possibility that there will not be enough fishing to thin out the stock sufficiently to protect the food supply. The key to the maintenance of a high average size is the rate at which the fish are thinned out by the anglers.

The third question is the one often asked by the tax-payer: is the cost of this management justified? The answer is apparently in the affirmative. Kamloops trout fry are worth about $3.00 per thousand and the Paul Lake planting cost about $600.00. It was conservatively estimated that the money brought into the Kamloops district from the outside, as a result of the Paul Lake attraction, amounted to about $10,000.00 per year. This represented a considerable return to those catering to the anglers. In addition, local residents derived consider-

able enjoyment from the fishing provided, and the surplus fry produced were in themselves worth over $2,000.00. On the whole, the venture seemed to be extremely worthwhile. Whether management programs of this type would be justified for other lakes, however, must be decided by a study of the merits of each body of water. Such a decision can only be made after adequate surveys and experiments have been carried out, which means investment in research.

The writer is indebted to the Fisheries Research Board of Canada, under whose auspices the investigations were conducted, for permission to publish the data.

## Literature Cited

Embody, G. C.
1927. An outline of a stream study and the development of a stocking policy. Contributions from Aquicultural Laboratory of Cornell University, pp. 1-21.

Mottley, C. McC.
1932. The propagation of trout in the Kamloops District, British Columbia. Trans. Am. Fish. Soc., Vol. 62, pp. 109-116.
1934. The effect of temperature during development on the number of scales in the Kamloops trout, *Salmo kamloops*, Jordan. Contr. Can. Biol. & Fish., Vol. VIII, No. 20. (Series A, General, No. 41), pp. 255-263.
1936a. A biometrical study of the Kamloops trout of Kootenay Lake, *Salmo kamloops*, Jordan. Jour. Biol. Bd. Can., Vol. 2, No. 4, pp. 359-377.
1936b. The classification of the rainbow trout of British Columbia. Prog. Rep. Pac. Biol. Sta., No. 27, pp. 3-5.
1937a. The loss of weight by rainbow trout at spawning time. Trans. Am. Fish. Soc., Vol. 67, pp. 207-210.
1937b. Does the full moon affect rainbow trout fishing. Trans. Am. Fish. Soc., Vol. 67, pp. 212-214.
1938. Fluctuations in the intensity of the spawning runs of rainbow trout at Paul Lake. J. Fish. Res. Bd. Can., Vol. 4, No. 2, pp. 69-87.

Mottley, C. McC., and Jean C. Mottley.
1932. The food of the Kamloops trout. Prog. Rep. Pac. Biol. Sta., No. 13, pp. 8-12.

Rawson, D. S.
1934. Productivity studies in lakes of the Kamloops region, British Columbia. Bull. Biol. Bd. Can., No. XLII, pp. 1-31.

# PRELIMINARY OBSERVATIONS AND EXPERIMENTAL STUDY OF THE LING, *LOTA MACULOSA* (LeSUEUR), IN WYOMING


Eugene E. Bjorn

*Wyoming Game and Fish Commission, Cheyenne*


## Introduction

The ling (also called lake lawyer, burbot, or eel pout) has long been regarded highly in Wyoming as a source of food by those living in the localities where it is found. In recent years the interest of the sportsmen of this state and adjoining states has been so aroused that "ling fishing" has become one of our outstanding winter attractions. It was estimated that over 15,000 fish, averaging about 2 pounds in weight, were taken from a single lake last season, and since specimens weighing as much as 24 pounds have been taken, the interest is further stimulated by the possibility of landing a "big one."

Not only does the ling appeal to residents of the state because of its excellence as a food, but it also provides a source of revenue by attracting fishermen to the central part of the state at a time when there is a lull in other forms of sport. The open season for ling is during the months of December, January and February after the big-game hunting seasons are over and before the spring fishing seasons have begun. Many "dude" ranchers, who ordinarily have no business at this time, benefit by accommodating visiting fishermen.

The ever-increasing demand for the ling threatens to make serious inroads upon the supply, and consequently, steps have been taken to protect the species against a rapid decrease in numbers. After the 1939 Legislature had adjourned, the ling held the legal designation of a "game fish" and now receives protection along with other game species.

The Game and Fish Commission sent a party into the field during February, 1939, to study the habits of the ling and determine the possibilities of its artificial propagation. The investigation was conducted over a period of two weeks during which time two lakes were visited and approximately one hundred specimens were examined. Due to the limited extent of the study and the lack of proper hatchery facilities, the results of these preliminary observations cannot be considered conclusive. However, the work will be continued.

The results of the present investigation show something of the feeding and breeding habits of the ling in Wyoming, and demonstrate that the species can be propagated artificially. Special attention has been given to the types of food taken, the season during which the ling spawns in different lakes, the size of the eggs and number of eggs produced per fish, the collecting of eggs and their hatching under artificial conditions.

## Materials and Methods

Most of the fish examined were taken through holes in the ice by means of short set lines baited with live minnows; others were taken in a gill net stretched across a small stream tributary to one of the lakes.

The fish used in the spawn-taking experiment were transported in fish cans to the Dubois Hatchery, where they were held in tubs until the experiment was completed. The eggs were stripped into a dry spawning pan and the milt from the male added immediately. The two were mixed thoroughly with the fingers until the eggs became cohesive; water was then added to cover the eggs and the pan set aside for five minutes to permit the completion of fertilization. The excess milt was then washed from the pan and the eggs placed in water for thirty minutes to water-harden; after water-hardening they were measured and placed on trout hatchery trays, the screens of which were replaced with muslin cloth to hold the small ling eggs. The trays were not disturbed during the entire process of incubation.

A stage micrometer was used to measure the diameters of the eggs which had been preserved in 2 per cent formalin until the measurements could be completed in the laboratory.

The number of eggs per fish was determined by counting the eggs in several small unit volumes, then multiplying the average by the total volume.

The stomach analyses were conducted to determine the types of food present, but little attention was given to the volume. Bait minnows taken from the hooks were not included in the analyses of the stomach contents. In determining the percentage of fish feeding on specific forms, specimens with empty stomachs were disregarded.

## Spawning Season and the Number of Eggs per Female

The spawning season of the ling continues over a period of three months, beginning in December and extending through February, as indicated by the condition of fish from two lakes, Ocean and Ring. Sixty-three specimens were taken from Ocean Lake during a period of four days, from February 6 to 10. Examinations revealed that only four of them had not spawned, and that many of the spent fish had spawned some time previously. The residents near the lake reported that milt flowed freely from the males taken in December and the first part of January. Obviously the spawning season was practically terminated at this lake in early February. Thirty-four specimens were examined from Ring Lake from February 15 to 18. Milt could be taken from nearly all of the males. One of the females had spawned, three were ripe and were stripped of their eggs, and it was estimated that the remaining females would spawn within two weeks. Sportsmen in the vicinity reported that they had observed fish on the spawning beds from about the middle of February to the first part of March.

The differences in the time of the spawning seasons in the two lakes can possibly be attributed to the different environmental conditions. Ocean Lake is located in the open foothills at an altitude of 5,214 feet. It has a surface area of 4,061 acres and a maximum depth of 18 feet. The lake is supplied by seepage from summer irrigation water, and has no definite inlet or outlet. The surface temperature is comparatively high in the summer (68° F. on September 9, 1938), but doubtless drops quickly with the advent of cold weather. Ring Lake is located in the mountains at an altitude of about 7,000 feet. It has a surface area of 94 acres and a maximum depth of 34 feet. The lake is supplied with a fairly large permanent inlet and obviously has a more constant temperature than Ocean Lake.

Spawning fish were taken near the inlet of Ring Lake during their migration to the spawning bed, which is a large hole in the creek bed about one-half mile above the lake. Examinations revealed that female ling in Ring Lake spawn when about 12 inches in length and that males are sexually mature when 9 inches in length.

It will be noted from Table 1 that there is a great variation in the number of eggs per unit volume. This circumstance can be attributed to the fact that the eggs varied considerably in the extent of their development; that is, some were very green and some were nearly ripe. Furthermore, some of the more nearly developed eggs may have begun to water-harden during the measuring process. In any event, the samples to be counted were taken immediately after the total volume had been determined, thus eliminating, as nearly as possible, the chance for error due to the change in the eggs while being measured. The information presented in Table 1 indicates that the female ling produces approximately 175,000 eggs per pound of fish.

**TABLE 1. ESTIMATE OF THE NUMBER OF EGGS PRODUCED PER FISH**

| Weight of fish in pounds | Total length of fish in inches | Volume of eggs in cubic centimeters | Average number of eggs per cubic centimeter | Total number of eggs per fish |
|---|---|---|---|---|
| 3/8 | 12 | 29.6 | 2,179 | 64,498 |
| 2 3/8 | 22 1/2 | 285.0 | 1,578 | 451,473 |
| 3 1/2 | 24 5/8 | 211.0 | 2,477 | 522,385 |
| 8 | 33 | 540.0 | 2,674 | 1,444,122 |

## Artificial Propagation

The fully developed eggs are of a clear light yellow color, are semibuoyant, and have a diameter of slightly over 1 millimeter. The eggs that were measured were taken from a 20-inch fish that weighed 1½ pounds. The average diameter of the eggs was found to be 1.041 millimeters after fertilization and water-hardening and 1.084 millimeters four days before hatching. There were 1,118 unfertilized, water-hardened eggs in a cubic-centimeter sample, and 33,093 in a fluid ounce.

The first eggs were taken February 16. After they had water-hardened and had been poured into the trays, they showed no signs of sticking together and moved freely when the flow of water in the trough was properly regulated. However, after two days the free movement ceased, and the water was forced up among the small clusters of eggs which had formed. The water remained at a constant temperature of 43° F., and the eggs began to hatch thirty days after incubation had begun. On February 18, the survey party left the field, and the experiment was placed in the hands of the superintendent of the State Hatchery. Every four days a sample was sent to the Department office for further investigation.

Fungus was first noticed in the trays after twelve days of incubation. Since the eggs were too small to be "picked" and were not treated, the fungus spread rapidly. The eggs and newly hatched fry showed an unusual resistance to the attack of the fungus, though undoubtedly many were killed. It was not uncommon to find living eyed eggs in a solid growth of fungus, and the hatchery superintendent reported that when the eggs began to hatch many small fish were seen emerging from within heavy growths of fungus. No attempt was made to hold and feed the young fish in the hatchery.

## Winter Food of the Ling

Food samples taken from Ocean Lake revealed that Amphipoda, Zygoptera nymphs, and Diptera larvae were particularly abundant. The extent to which these forms are utilized for food by the ling may be seen in Table 2. Since Diptera larvae were not contained in specimens over 22 inches in length, the information indicates that the larger fish show a preference for the larger types of food. This point is further illustrated by data (also obtained in February) from Ring Lake. Diptera larvae were represented in 40 per cent of the stomachs examined from fish that ranged from 9 to 18 inches in length, and were not present in the stomach contents of the larger fish.

**TABLE 2. SUMMARY OF STOMACH EXAMINATIONS OF THE LING**

| Item | Percentage of ling from Ocean Lake containing the food indicated | Percentage of ling from Ring Lake containing the food indicated | Percentage of ling containing the food indicated |
|---|---|---|---|
| **Number and size of fish** | **38 specimens 18 to 25 inches long** | **34 specimens 9 to 33 inches long** | **72 specimens 9 to 33 inches long** |
| Plecoptera; stonefly nymphs | 0.0 | 33.0 | 11.5 |
| Trichoptera; caddisfly larvae | 19.0 | 8.5 | 14.5 |
| Ephemeroptera; mayfly nymphs | 14.0 | 0.0 | 8.5 |
| Diptera; larvae | 9.5 | 16.5 | 11.5 |
| Zygoptera; damselfly nymphs | 90.5 | 8.5 | 58.5 |
| Anisoptera; dragonfly nymphs | 23.8 | 0.0 | 14.5 |
| Amphipoda; scuds | 74.0 | 25.0 | 55.8 |
| Mollusca; snails | 9.5 | 8.5 | 9.0 |
| Vegetation; higher plants | 23.8 | 16.5 | 20.5 |
| Fish | 47.5 | 66.8 | 56.0 |

## Summary

1. The ling spawns in Ocean and Ring Lakes during the months of December, January and February. Due to differences in environmental conditions, the spawning period is earlier in Ocean Lake than in Ring Lake.

2. Female ling are sexually mature when 12 inches in length, and males when 9 inches in length.

3. The female ling produces approximately 175,000 eggs per pound of weight.

4. The average diameter of water-hardened eggs from a ling 20 inches in length and 1½ pounds in weight was 1.041 millimeters.

5. Ling eggs can be taken, fertilized, and hatched under artificial conditions. The incubation period is 30 days at a temperature of 43° F.

6. In winter the food consists of aquatic insects, Amphipoda Mollusca, and fish. The extent to which ling feed on fishes is inversely related to the accessibility of other types of food. Small ling feed extensively on Diptera larvae and other small food organisms.

# EFFECTS OF A DECREASED OXYGEN SUPPLY ON SOCKEYE AND CHINOOK SALMON

WILBERT McLEOD CHAPMAN

*State of Washington*
*Department of Fisheries, Seattle*

ABSTRACT

**A study was made of the minimum concentration of oxygen in the water necessary to maintain sockeye and chinook salmon in normal condition. It was found that when the oxygen content of the water was reduced to 3.5 p.p.m. salmon showed definite signs of distress; a reduction below 3.0 p.p.m. caused the death of some fish; a reduction below 2.5 p.p.m. brought about the asphyxiation of most of the fish in a short time. Considerable individual variation was found, some fish not dying until the oxygen concentration had dropped to 1.2 p.p.m. Some notes also are presented concerning the reaction of suckers and carp to a diminished oxygen supply.**

## INTRODUCTION

The respirational necessities of salmon are of practical as well as physiological interest. For the sake of economy it is desirable to crowd the fish in handling them in the hatchery system. Also, one of the outstanding effects of many pollutants on the salmon streams is to lower the oxygen content of the water to a point where the life of the fish is endangered. While the relationship between a reduction in the oxygen content of the water and the asphyxiation of fishes has been widely studied (König and Hünnemeier, 1901; Kupzis, 1901; Wells, 1913; Krogh and Leitsch, 1914; Keyes, 1931), only Gardner and Leetham (1914) and Gutsell (1929) have worked extensively with salmonoid fishes, and no one has studied the Pacific salmons of the genus *Oncorhynchus*. A series of experiments were undertaken to determine the minimum oxygen concentration of the water in which chinook and sockeye salmon could exist without evident distress.

## METHODS

The experiments were conducted with adult fish in the field under normal conditions of transportation, in the laboratory with young fish, and in the hatchery with newly-hatched fish.

The apparatus used in the field experiment was a rectangular steel tank of 800-gallon capacity, mounted on a motor truck. The tank was equipped with a pump by which the water it contained could be circulated to prevent stratification. A No. 2 Roper gear pump was mounted on the intake line ahead of the circulating pump so that when the pumps were running a steady stream of air was forced into the circulating water. The air pump could be disconnected so that only the water pump was operating. The surface of the water in the tank was exposed to the air so that there was opportunity for gaseous

interchange between the water and atmosphere, even though the door on top of the tank (which was not air-tight) was closed. Oxygen and carbon-dioxide samples were taken by immersing a 200 c.c. glass-stoppered bottle about a foot beneath the surface of the water. The samples were analyzed directly after being taken. Water from the Columbia River at Rock Island was used in the experiments.

The apparatus used in the laboratory was a 5-gallon glass demijohn with a narrow neck. The demijohn was fitted with a three-hole rubber stopper, for the inlet, outlet and a thermometer. The outlet was flush with the bottom of the stopper so that no air was trapped in the container. The inlet projected to within an inch of the bottom of the demijohn. Tests with ink showed that the circulation of water was rapid and thorough in all parts of the container. Seattle tap water was used in all of the laboratory experiments. In order to eliminate small bubbles of air from the water and to equalize the fluctuating pressure in the water main, it was found necessary to insert another demijohn in the line between the tap and the apparatus and siphon the water from it. The rate of flow was regulated by pinch clamps and by raising or lowering the siphon demijohn.

The young fish in the laboratory experiments were all starved at least twenty-four hours before being placed in the apparatus. The adult fish had been in fresh water for at least three weeks and had not, presumably, eaten during that time. No attempt was made to control external stimuli, such as noise, vibrations, etc., because it was desired to study the reaction under conditions that approximated normal. The fishes used in the experiments were: sockeye salmon (*Oncorhynchus nerka*); chinook salmon (*Oncorhynchus tschawytscha*); small-scaled sucker (*Catostomus syncheilus*), carp (*Cyprinus carpio*), squawfish (*Ptychocheilus oregonensis*), and chub (*Mylocheilus caurinus*).

The oxygen determinations were made by the unmodified Winkler method as given in "Standard Methods of Water Analysis." The $CO_2$ determinations were made by titrating against N/44 sodium hydroxide with a phenolphthalein indicator. Determinations of pH were made with a Hellige hydrogen-ion comparator, Model No. 607. Temperatures were taken with a thermometer graduated by intervals of 0.1° C.

The chemical tests were all made as soon as the sample was taken. The determinations in the field were made by Mr. R. T. Smith of the State Department of Fisheries. Acknowledgment is made of the laboratory facilities provided by the School of Fisheries, University of Washington, and of the assistance given by Dr. Lauren R. Donaldson of that school.

## Minimum Oxygen Concentrations for Adult Salmon

**Experiment 1.** On August 2, 1937, ten sockeye salmon, six suckers, and five squawfish were placed in the tank. At that time the oxygen content of the water was 8.1 p.p.m., the free $CO_2$ content of the water

was 0.25 p.p.m., and the water temperature was 18.8°C. The air and circulating pumps were not used. The first definite reaction of the fish was noted at the end of six hours, when the salmon began to jump a little and gulp at the surface. The oxygen content of the water was then 2.7 p.p.m., the $CO_2$ content 2.3 p.p.m., and the water temperature was 21.1° C. In another half hour the oxygen content of the water had dropped to 2.5 p.p.m., and the salmon appeared to have lost a large part of their senses of touch and sight, and were generally less reactive. They swam slowly, collided with one another and with the walls of the tank. In another fifteen minutes two sockeye had turned over on their backs and ceased swimming. The oxygen content of the water was then 2.4 p.p.m.

**Experiment 2.** On August 4, 1937, one chinook salmon, six sockeye salmon, thirty-three suckers, one squawfish and one lamprey were placed in the tank. The oxygen content of the water was 7.9 p.p.m., the $CO_2$ content was 0.25 p.p.m., and the water temperature was 17.1° C. The first reaction of the fish was noted after a lapse of four hours, when four of the sockeye were seen swimming at the top of the tank. The oxygen content of the water was 2.9 p.p.m., the $CO_2$ content 2.3 p.p.m., and the water temperature was 19.4° C. In another hour the blueback exhibited lack of coordination as they had in Experiment 1. The oxygen content of the water had dropped to 2.5 p.p.m. In another hour the oxygen content had reached 2.4 p.p.m., and two sockeye had succumbed. The chinook had now begun to show distress and in another forty minutes it turned over on its back. By this time, five of the sockeye had died. The oxygen content then was 2.3 p.p.m., the $CO_2$ content 3.0 p.p.m., and the water temperature 21.2° C. The suckers and squawfish showed no distress.

**Experiment 3.** On August 5, 1937, three chinook salmon, twenty-six sockeye salmon, sixty-one suckers, seven squawfish, two chubs, and one carp were placed in the tank. The oxygen content of the water was 8.4 p.p.m., the $CO_2$ content 0.25 p.p.m., the pH 8.0, and the water temperature 20.2° C. Within two and one-half hours all the sockeye and two of the chinook salmon were dead and the third chinook was in a weakened condition. At that time the oxygen content was 2.7 p.p.m., the $CO_2$ content 2.5 p.p.m., the pH 6.9, and the water temperature 22.5° C. In another half hour the suckers and squawfish were rising to the surface and gulping. The oxygen content of the water was 2.0 p.p.m. The first sucker succumbed a half hour later when the oxygen content of the water had dropped to 1.6 p.p.m. The experiment was continued for another hour. By that time twenty-eight suckers and one squawfish had eased swimming and turned on their backs. The carp had shown no sign of distress. The oxygen content of the water was 1.35 p.p.m., the $CO_2$ content 4.3 p.p.m., the pH was 6.7, and the temperature of the water was 23.0° C.

**Experiment 4.** To determine whether the deleterious effects on the fish noted in the foregoing experiments were due to low oxygen con-

centrations and not to changes in pH or increased $CO_2$ concentrations the following experiment was conducted.

On August 6, 1937, five chinook salmon, sixty sockeye salmon, forty suckers, four squawfish and one chub (about 400 pounds of fish) were placed in the tank and kept there four hours. The oxygen content of the water was held at 5.3 p.p.m. or more for the whole period, the pH dropped to 6.9, and the $CO_2$ content of the water increased to 4.0 p.p.m. The latter two factors were lower and higher, respectively, than the salmon had been subjected to in the first three experiments. At the end of four hours the fish appeared to be in perfectly normal condition. It therefore seems evident that the increased carbon-dioxide concentrations and the lower pH were not the causative factors in the abnormal reactions of the fish in Experiments 1, 2, and 3, when the oxygen concentration was reduced.

## Minimum Oxygen Concentrations for Salmon Fry

The fish used in these laboratory experiments were young chinook salmon which had absorbed most of their yolk and had the yolk sac scar healing. These fish averaged 0.51 gram each in weight.

**Experiment 5.** On February 18, 1938, five hundred of the small chinook salmon were placed in a 5-gallon demijohn in which the water temperature was 19.6° C. The flow of water through the apparatus was cut to one liter in five minutes, twenty seconds. Oxygen samples were taken from the outlet at intervals of ten minutes. The same rate of flow was maintained throughout the experiment.

The movements of the young fish in the glass container gave a much more delicate indication of the effect of oxygen deficiency than was available in the work with the adult fish. When the oxygen concentration in the water was adequate for the respiration of the salmon, they were about equally distributed throughout the container. The first signs of distress from oxygen deficiency were shown when the fish tended to concentrate near the outlet at the top and to settle at the bottom. The distress was accompanied by an acceleration in the rate of swimming and an increase in the rate of gill movements as the oxygen content of the water decreased. The fish that had congregated near the outlet at the top were in the region of the jar where there was the least oxygen. After struggling for a time at that point, they became exhausted and sank slowly to the bottom. The water on the bottom was richer in oxygen and the fish would soon recover and again swim to the top, only to repeat the process. As the oxygen content of the water decreased, more and more of the fish were affected and began to participate in the movement characteristic of distress, until at last all the fish had congregated at the bottom of the jar.

The tendency of the fish to leave the middle of the jar and congregate at the top and bottom was first noticed after fifty minutes, when the oxygen content of the water was 3.59 p.p.m. The congregating of the young chinook increased as the oxygen decreased until nearly all

the fish were either at the top or bottom of the jar at the end of the experiment, when the oxygen content of the water was 3.07 p.p.m. No deaths occurred, but thorough distress was exhibited by all of the fish.

**Experiment 6.** On February 19, 1938, a similar experiment was conducted. Five hundred young chinook salmon having a total weight of 272 grams were placed in the apparatus containing water with a temperature of 19.2° C.; another 500, weighing 268 grams, were placed in a second container in which the water temperature was 13.5° C. The rate of flow in both jars was reduced to one liter in six minutes, thirty-six seconds. This rate of flow was maintained throughout the experiment. Simultaneous oxygen samples were taken at fifteen-minute intervals from the outlets of both jars.

In Jar 1 the fish first showed distress after 2.5 hours at an oxygen content of 3.30 p.p.m. One hour and fifteen minutes later the oxygen content of the water had been reduced to 2.66 p.p.m. Most of the fish were in distress. The water flow was returned to normal. The next day, 105 of the 500 fish had not recovered. The temperature of the water had increased to 15.8° C.

In Jar 2 the fish first showed distress after one-half hour at an oxygen concentration of 3.22 p.p.m. In another hour, the oxygen content of the water had been reduced to 2.16 p.p.m. By that time, about 60 per cent of the stock were on the bottom in an exhausted condition. The rate of swimming of those remaining upright had diminished greatly. The carbon-dioxide content of the water was 11.75 p.p.m. The temperature of the water had increased to 20.1° C.

**Experiment 7.** On February 11, 1938, 760 chinook fingerlings were placed in the experimental apparatus. There was no circulation of water through the apparatus but air was bubbled through to replace the oxygen used by the fish. In two hours the $CO_2$ content of the water was 11.75 p.p.m. The fish were retained continuously in the jar for forty-eight hours. During that period, the oxygen content of the water remained above 4.0 p.p.m. at all times, and the $CO_2$ content ranged between 11.75 and 14.50 p.p.m. Throughout the two-day interval the fish appeared to be perfectly normal in their reactions. There were no deaths and no apparent distress. This experiment demonstrated again that the deleterious effects noted were due to oxygen deficiency and not to the toxicity of the increased carbon-dioxide content of the water.

## Experiments at the Green River Hatchery

Some observations were made at the Green River Hatchery of the Washington State Department of Fisheries. The silver salmon (*Oncorhynchus kisutch*) used for the experiments were contained in forty-five trays, 2 inches deep, placed in a trough in nine racks that held five trays each. The yolk sac scar on the fish was just healing. The fish averaged 1,600 to the pound. The total calculated weight of the 316,000 fish in the trough was 197.5 pounds (wet weight).

On March 2, 1939, the water flow in the trough was reduced to 10.5 gallons per minute. In two hours the oxygen content of the water at the foot of the trough had ceased decreasing. When stability was reached the oxygen content of the water at the head of the trough was 11.20 p.p.m., and at the foot 2.58 p.p.m. The fish in the last five of the nine sections in the trough were definitely being asphyxiated. Although they were still alive, most of them were lying on their sides and had nearly ceased movement. The flow of water in the trough then was returned to normal, and within one-half hour the fish had recovered, apparently without any ill effects.

## Discussion

The conclusions reached in the experiments with adult salmon were found to be applicable to fingerlings as well. However, it was also determined that the small fish, at least, manifested a definite reaction to oxygen deficiency when the oxygen content was reduced to about 3.5 p.p.m.

The salmon showed considerable individual variation in their toleration of oxygen deficiency. In a large group of fish a few always became asphyxiated when the oxygen content of the water fell much below 3.0 p.p.m. However, death did not necessarily ensue immediately, nor were all the fish affected at the same time or level of oxygen concentration. Also, after collapsing completely and showing all the signs of complete asphyxiation for a considerable length of time, some fish returned rapidly to normalcy when the oxygen content of the water was increased above the danger point, while other individuals died. These facts were illustrated by the following experiences:

On February 10, 1939, fish were left overnight in two of the experimental jars through which the water circulated normally. Sometime during the night both outlets became plugged. The next morning all the fish in the first jar were dead. The oxygen content of the water was 1.2 p.p.m. Some of the fish had remained alive long enough to reduce the content that far below the normal danger point. In the other jar, all but 20 of the 800 fish had "keeled" over and were lying on their backs on the bottom. The oxygen content of the water had reached 1.8 p.p.m., but the twenty fish were still swimming. The fish on the bottom, although thoroughly exhausted, were not all dead. The water circulation was returned to normal and within one-half hour 50 per cent of the fish had recovered.

The conclusions based upon these investigations, therefore, are not comparable with the results of experiments conducted with only one or few specimens where individual variation would bulk large in the results. The conclusions from the present studies, which are given below, should be considered as statistical averages and not applicable to any single fish.

Gutsell (1929), who worked with brown, brook, and rainbow trout, concluded: "Some asphyxiation occurred with an $O_2$ content of about

2.5 p.p.m. Definite data for the interval 2.3-1.3 p.p.m. are lacking. With 1.3 or less, all trout were asphyxiated. Trout in an asphyxiant condition recovered in water containing as little as 2.67 p.p.m. $O_2$.'' These conclusions are in substantial agreement with the results of the present studies.

The results of Experiments 4 and 7 demonstrated that the other experiments reflected the effect of oxygen deficiency and not carbon dioxide excess, or at least that if the concentration of oxygen was kept above the danger point there would be no deleterious effects from a concentration of carbon dioxide of the magnitude found in these experiments. These conclusions are in accord with those of Gutsell (1929), who gives a good review of the literature on the subject. He stated (referring to the trout with which he worked): ''Carbon dioxide up to 28 p.p.m. was not markedly harmful. It did not appear that contents up to 39 p.p.m. increased the ill effects of reduced $O_2$.''

## Conclusions

1. When the oxygen content of the water was reduced to 3.5 p.p.m., the species of salmonoid fishes used for the experiments showed definite signs of distress.
2. When the oxygen content of the water was reduced to below 3.0 p.p.m., some of the salmon succumbed.
3. When the oxygen content of the water was reduced to below 2.5 p.p.m., most of the salmon died in a short time.
4. There is considerable individual variation in the ability of these fish to withstand oxygen depletion. All of the fish of a large group may not die until the oxygen content of the water has been reduced to 1.2 p.p.m., although all will exhibit serious distress before that point is reached.
5. When the oxygen content of the water was reduced as low as 2.0 p.p.m. or less, adult suckers of the species studied were in danger of asphyxiation.
6. When the oxygen content of the water reached 1.6 p.p.m. or less, the suckers died in a short time.
7. At an oxygen concentration of only 1.35 p.p.m., carp apparently did not suffer deleterious effects.
8. A gradual increase of the carbon-dioxide content of the water to as much as 14.5 p.p.m. caused no visible deleterious effects on the young salmon within forty-eight hours so long as the oxygen content of the water was maintained above 4.0 p.p.m.

## Literature Cited

American Public Health Association.
1933. Standard methods for the examination of water and sewage. Seventh edition, pp. 1-180.

Davidson, F. A.
1933. Temporary high carbon dioxide content in an Alaskan stream at sunset. Ecology, Vol. 14, pp. 238-240.

Gardner, J. A., and C. Leetham.
1914. On the respiratory exchange in fresh water fish. Part II. On brown trout. Biochemical Journal, Vol. 8, pp. 591-597.

Gutsell, J. S.
1929. Influence of certain water conditions, especially dissolved gases, on trout. Ecology, Vol. 10, No. 1, pp. 77-96.

Keyes, A. B.
1931. A study of the selective action of decreased salinity and of asphyxiation on the Pacific killifish, *Fundulus parvipinnis*. Bulletin, Scripps Institution of Oceanography, Technical Series, Vol. 2, No. 12, pp. 417-490.

König, J., und B. Hünnemeier.
1901. Ueber den niedrigsten für das Leben der Fische notwendigen Sauerstoffgehalt des Wassers. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel, sowie der Gebrauchsgegenstände, Bd. 4, S. 385-391.

Krogh, H., and L. Leitsch.
1919. The respiratory function of the blood in fishes. Journal of Physiology, Vol. 52, pp. 288-300.

Kupzis, J.
1901. Ueber den niedrigsten für das Leben der Fische notwendigen Sauerstoffgehalt des Wasser und über die fur dieselben giftigen Mengen im Wasser gelöster Kohlensäuere. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel, sowie der Gebrauchsgegenstände, Bd. 4, S. 631-638.

Wells, M. M.
1913. The resistance of fishes to different concentrations and combinations of oxygen and carbon dioxide. Biological Bulletin, Vol. 25, pp. 325-347.

# THE FOOD AND GROWTH OF THE YOUNG OF THE COMMON BULLHEAD, *AMEIURUS NEBULOSUS NEBULOSUS* (LESUEUR), IN CAYUGA LAKE, NEW YORK

EDWARD C. RANEY AND DWIGHT A. WEBSTER

*Cornell University, Ithaca, New York*

ABSTRACT

An analysis is presented of the food of 170 specimens of the young of the common bullhead, *Ameiurus nebulosus nebulosus* (LeSueur), taken at intervals from June 21 to October 10, 1938, in quiet coves of Cayuga Lake, Ithaca, New York. A large variety of organisms were utilized for food. The main staples were Crustacea (approximately 60 per cent) and Diptera (approximately 25 per cent). Almost all of the Diptera were chironomid larvae, while 80 per cent of the Crustacea were ostracods and cladocerans. Considerable variation in the length attained by the common bullheads was noted in the collections taken after the middle of July. By October 10 the largest specimen was more than twice the length of the smallest. While the mean total length does not exceed 3 inches at the end of the first growing season, some individuals may reach a total length of nearly 4 inches.

## INTRODUCTION

At intervals during the summer of 1938 collections of the young of the common bullhead, *Ameiurus nebulosus nebulosus* (LeSueur), were made in the coves leading off lower Fall Creek and Cayuga Lake, at Ithaca, New York. These quiet coves have ooze bottoms and a plentiful supply of aquatic vegetation. The most common plants are water clover, *Marsilea quadrifolia,* spatterdock *Nymphozanthus advena,* and several species of pondweed, *Potamogeton.* Adult bullheads move into the coves in numbers when the water temperature has reached 50 to 55° F., which occurs usually during the first two weeks of April. At this time the bullheads feed avidly. Spawning occurs mostly during the first three weeks in June and the young may be seen commonly thereafter, at first in dense schools and later scattered among the aquatic plants. Wright and Allen (1913, p. 4), have stated the breeding dates for Ithaca as May 20 to July 1.

Specimens were preserved immediately after collection in 10 per cent formalin and later were transferred to and stored in 70 per cent alcohol. The measurements and analyses were made of these preserved specimens.

Many isolated reports have appeared giving data on the food of the common bullhead. The majority of these papers considered only the adults or did not mention the size of the fish examined. Adams and Hankinson (1928, p. 375) have summarized the published food studies, and it is apparent from these studies that "the common bullhead feeds upon a large variety of food." It consumes small fish, mollusks, insects (largely aquatic), leeches, earthworms, crayfish, and other crustaceans. No thorough study has been made of the growth rate of the

common bullhead but Greeley (1930, p. 82) noted that "the size varies from several pounds in Lake Champlain to several ounces in certain cold ponds of the Adirondacks."

## Food

*Method*—The alimentary tract was removed from each specimen and its contents examined with the aid of a binocular microscope. The percentage of the total volume contributed by each organism was then estimated. A source of error was recognized in estimating the volume of intestinal contents in that certain soft bodied organisms, such as the larvae of *Chironomus*, are digested more rapidly than the hard bodied species, for example, ostracods whose outer shell may remain in the intestines for a considerable period. It is clear that if only the volume of the chitinized heads of *Chironomus* was considered but the volume of the entire body of the ostracod was measured an error would result. An attempt was made to compensate for this error by estimating the probable original volume rather than the actual volume of the food in the intestines. It was found impractical to list the food in percentage of frequency of occurrence. In all, 170 specimens were examined for food.

The stomachs of specimens collected during the day were often empty or contained only a few organisms, whereas those collected at dusk or at night almost invariably had the stomach filled to capacity. Diurnal variations in feeding habits of adults are well known to local fishermen, who fish principally during the evening and at night, although good catches are made occasionally during the day. Some evidence, obtained by diligent seining, indicated that adults may move into the coves at night where they had been absent during daylight hours.

*Results*—The data presented in Table 1 show the large variety of organisms utilized for food by young bullheads. Of interest is the fact that micro-organisms are not consumed by the youngest juveniles to the exclusion of other organisms. Other data not included in Table 1 demonstrate this fact even more strikingly. The food of twenty-five bullhead fry about three days old, averaging 9.9 millimeters standard length, taken over a rocky shore in Columbia Lake, Tolland County, Connecticut, was found to be approximately 50 per cent insect larvae (largely chironomids) and 50 per cent crustacea (Cladocera).

The main staples throughout the first season are drawn from Crustacea (approximately 60 per cent) and from Diptera (approximately 25 per cent). Almost all of the Diptera taken were chironomid larvae while 80 per cent of the Crustacea were ostracods and cladocerans. The results are similar to those obtained by Moore (1922, p. 56), who found that young common bullheads taken from July to September in Lake George, New York, and in various other ponds feed chiefly on midge larvae, waterfleas and other small crustacea. While most of the organisms taken are benthic or free-swimming in habit, the inclu-

**TABLE 1. SUMMARY OF THE FOOD OF *AMEIURUS NEBULOSUS NEBULOSUS* (LeSUEUR) BASED UPON THE EXAMINATION OF THE ALIMENTARY TRACT. (THE ESTIMATED VOLUME OF EACH ITEM IS GIVEN AS THE PERCENTAGE OF THE TOTAL VOLUME.)**

| | Date collected, 1938 | | | | | | |
|---|---|---|---|---|---|---|---|
| Item | June 21 | June 30 | July 15 | Aug. 5 | Sept. 30 | Oct. 10 | Total[1] |
| **Number examined** | 30 | 25 | 25 | 36 | 28 | 26 | 170 |
| **Mean standard length in millimeters** | 12.9 | 18.1 | 26.9 | 35.2 | 47.7 | 56.3 | ...... |
| Bryozoa | 0.5 | ...... | 0.5 | ...... | ...... | 7.5 | 1.4 |
| Arthropoda | | | | | | | |
| Insecta[2] | | | | | | | |
| Ephemeroptera | ...... | ...... | ...... | 7.0 | ...... | ...... | 1.2 |
| Odonata | 0.5 | ...... | 3.5 | ...... | 5.0 | 6.5 | 2.6 |
| Trichoptera | ...... | ...... | ...... | 1.0 | ...... | 5.5 | 1.1 |
| Hemiptera | ...... | ...... | ...... | ...... | ...... | 0.5 | 0.1 |
| Coleoptera | ...... | 0.6 | 4.5 | ...... | 2.5 | 1.0 | 1.4 |
| Diptera | 3.5 | 31.7 | 8.0 | 46.5 | 10.0 | 46.5 | 24.3 |
| Undetermined | 1.2 | 0.6 | 1.0 | 3.5 | 21.3 | 8.5 | 6.0 |
| Crustacea | | | | | | | |
| Cladocera | 69.0 | 37.0 | 38.5 | 0.5 | 4.5 | 0.3 | 25.0 |
| Ostracoda | 19.0 | 18.8 | 34.0 | 37.0 | 7.0 | 7.5 | 20.5 |
| Copepoda | 3.5 | 9.0 | 9.5 | 3.0 | ...... | 0.7 | 4.3 |
| Isopoda | ...... | ...... | ...... | ...... | 40.0 | ...... | 6.7 |
| Amphipoda | 0.5 | 1.3 | ...... | ...... | 7.2 | 5.5 | 2.4 |
| Pisces | | | | | | | |
| Eggs | 1.3 | ...... | ...... | ...... | ...... | ...... | 0.2 |
| Remains | ...... | ...... | ...... | ...... | ...... | 6.5 | 1.1 |
| Miscellaneous[3] | 1.0 | 1.0 | 0.5 | 1.5 | 2.5 | 3.5 | 1.7 |

[1]Based on 100 per cent.

[2]The insects were almost entirely aquatic larvae.

[3]Miscellaneous food included those organisms which occurred only as traces, including the following: rotifers, insect eggs, mites, oligochaete worms, snails, Protozoa (*Difflugia*), algae and higher plant remains.

sion of a few adult dipterans as well as the statoblasts of bryozoans indicate that the young bullheads do, on occasion, feed on the surface of the water. Actual observation of feeding young substantiates this fact. Fishes or fish eggs probably form a small percentage (1.3 in this study) of the food of young bullheads; the fish remains included in Table 1 were those of a cyprinid. Ewers and Boesel (1935, p. 58) found the food of twenty-seven black bullheads, *Ameiurus melas*, from Buckeye Lake, Ohio, ranging from 29 to 55 millimeters in total length, to be predominantly crustaceans, "to the extent of 74.07 per cent, with Cladocera and Copepoda about equally well represented on the basis of volume. Insects were present to the extent of 12.22 per cent. All the insects found were Chironomidae, particularly larvae, but also pupae and adults."

As might be expected, with an increase in the size of the young there was also an increase in the size of the particles utilized as food. This correlation is shown in Figure 1. The importance of the relationship is increased when it is realized that the organisms included in the "other food" curve (Figure 1) are forms such as *Hyallela* and *Asellus* of a size comparable to insect larvae.

What part the availability of food played in determining the change in the size of the organism eaten cannot be reported in this paper be-

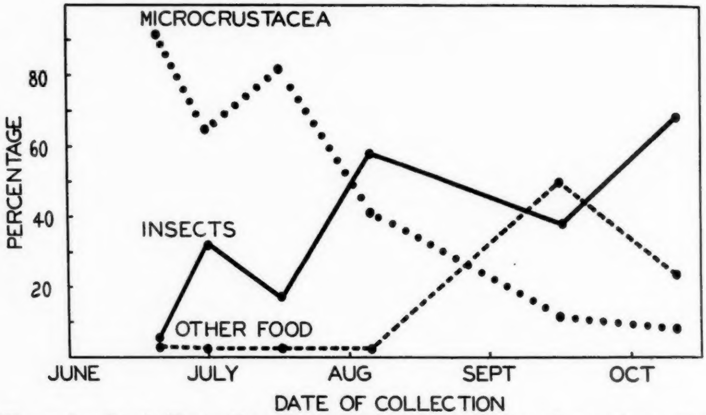


**Figure 1.**—Graph illustrating the change in kind and size of organisms eaten by young bullheads during their first summer in Cayuga Lake, New York. The size of the fish on the date of capture may be found in Table 2.

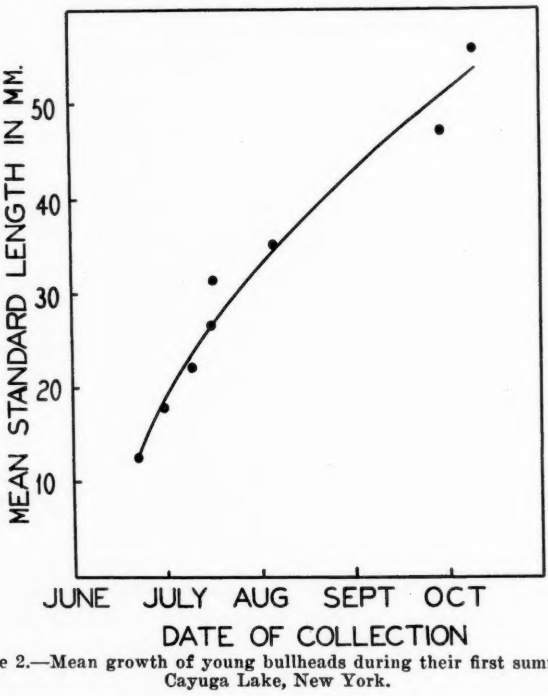


**Figure 2.**—Mean growth of young bullheads during their first summer in Cayuga Lake, New York.

cause qualitative or quantitative studies of the food organisms available were not undertaken.

## Growth

The data obtained on the growth of the young bullheads are summarized in Table 2 and a growth curve is given in Figure 2. Considerable variation in size was observed in the collections made after the middle of July. By October 10 the largest specimen was more than twice the size of the smallest. Whereas the mean total length did not exceed 3 inches at the end of the first growing season, a few individuals reached a total length of 4 inches.

**TABLE 2. GROWTH OF YOUNG *AMEIURUS NEBULOSUS NEBULOSUS* (LeSUEUR) TAKEN IN CAYUGA LAKE, NEW YORK, DURING THE SUMMER OF 1938**

| Date collected, 1938 | Number[1] measured | Standard length (millimeters) | | Total length (millimeters) | | Equivalent mean total length (inches) |
|---|---|---|---|---|---|---|
| | | Range | Mean | Range | Mean | |
| June 21 | 100 | 12 to 14 | 12.9 | 13 to 16 | 15.2 | 0.6 |
| June 30 | 97 | 14 to 21 | 18.1 | 16 to 25 | 20.9 | 0.8 |
| July 8 | 100 | 18 to 26 | 22.4 | 20 to 31 | 26.8 | 1.1 |
| July 15 | 65 | 20 to 36 | 26.9 | 23 to 38 | 31.6 | 1.2 |
| July 16 | 100 | 24 to 38 | 31.8 | 28 to 44 | 36.9 | 1.5 |
| August 5 | 63 | 30 to 48 | 35.2 | 35 to 48 | 42.0 | 1.7 |
| September 30 | 27 | 37 to 65 | 47.7 | 45 to 79 | 57.5 | 2.3 |
| October 10 | 53 | 35 to 77 | 56.3 | 41 to 93 | 68.0 | 2.7 |

[1]When less than 100 specimens were measured that number represents all the specimens collected.

## Literature Cited

Adams, Charles C., and Thomas L. Hankinson.
1928. The ecology and economics of Oneida Lake fish. Roosevelt Wild Life Annals, Vol. 1, Nos. 3-4. Bull. N. Y. St. Coll. Forestry, Vol. 1, No. 4a, pp. 235-548, figs. 175-244, pls. 1-4, map 16.

Ewers, Lela A., and M. W. Boesel.
1935. The food of some Buckeye Lake fishes. Trans. Amer. Fish Soc., Vol. 63, pp. 57-70.

Greeley, J. R.
1930. Fishes of the Lake Champlain Watershed. In: A Biological Survey of the Champlain Watershed. Supplemental to Nineteenth Annual Report of the New York State Conservation Department, 1929, pp. 44-87.

Moore, Emmeline.
1922. The primary sources of food of certain food and game, and bait fishes, of Lake George. In: A Biological Survey of Lake George, N. Y. State of New York Conservation Commission, 1922, pp. 52-63, figs. 24-26.

Wright, A. H., and A. A. Allen.
1913. The Fauna of Ithaca, N. Y.: Fishes. Zoology Field Note-book, Ithaca, N. Y., pp. 4-6.

# AN ELECTRICAL METHOD OF COLLECTING FISH

DAVID C. HASKELL

*New York State Conservation Department, Gansevoort, N. Y.*

ABSTRACT

**An electrical method of collecting fish has been developed which appears to be successful in streams up to 20 feet in width, and depths not greater than can be waded. Fish stunned, and then collected with a scap net, recover when placed in fresh water, so that almost none die as a result of the shock. The method has been tested in hard and soft water and under a variety of stream conditions. Fish may be removed from areas where brush, boulders and other obstructions prohibit seining. Because the fish turn with the light-colored ventral side up when stunned they become more visible than when only the dorsal surface is exposed to the view. The method is effective for fish large enough to be seen easily when stunned, that is, fish 3 inches or more in length.**

## INTRODUCTION

Population studies play an important part in the solution of fish-management problems. Quantitative studies in streams usually depend principally on seining as a method of capture. Seining can be conducted successfully only in areas relatively free from obstructions, and even then its efficiency is questionable. Needham and Rayner (1939) reported one example where a section of stream yielded fifteen trout by seining, whereas 108 trout were found when the water flow was diverted to another channel and the stream dried up. Hager (1934), reviewed by Shetter (1938), used electric shock to remove fish from streams. On the basis of Hager's method and results, experiments were begun in February, 1939, to determine the possibilities of electric shock as a means of removing fish from streams.

## DESCRIPTION OF APPARATUS AND METHOD OF OPERATION

Hager (1934) used a 2-volt generator connected to electrodes 20 to 40 feet apart, but such a low voltage was found ineffective in our work. McMillan (1928) reported that a voltage considerably lower than that used for our study was sufficient to stun fish in aquaria. In a stream, however, fish will move away from an electric field unless the shock is severe enough to stun them quickly. McMillan also reported comparable results from the use of direct and alternating current in aquaria, but direct current was not effective in our stream work.

The source of power in our apparatus is a 110 to 220 volt, 60-cycle alternating current generator, preferably equipped with a field rheostat for adjusting the voltage. Experiments have demonstrated that a maximum output of 500 watts is sufficient for work in streams 20 feet wide. Power for the generator is supplied by a small gasoline engine, which together with the generator, is attached to a portable mounting. (Figure 1).

Figure 1.—A census by the electrical method in progress on Cold Spring Brook near Van Hornesville, New York.

One of the terminals of the generator is grounded by connecting it to an iron pipe driven into the stream bed near the shore (indicated by the black arrow in Figure 1). Since the resistance of the bottom soil of streams is usually much lower than the resistance of the water, grounding one of the generator terminals in this way causes the entire bottom of the stream to serve as one electrode. In some soils it will be found necessary to use a series of pipes spaced several feet apart, connected to each other by a continuous wire from the generator terminal.

The other terminal of the generator is connected by a long insulated flexible wire to a metal electrode, consisting of a strip of wire screening 4 to 6 inches wide and 10 to 15 feet long, with a wooden handle fastened to each end of the screen. With corks attached so that it will float on the surface of the water, the screen is stretched across the stream. Two men move the electrode up and down the test area, which has been blocked off by seines at each end. A third man with a scap net collects the stunned fish and a fourth unwinds the wire attached to the metal electrode and carries a pail to receive the fish.

As in any electrical work there is some shock hazard, although our experience has indicated that it is slight. All work should be done by capable men who understand the apparatus. It is advisable for the operators to wear rubber gloves and rubber boots to avoid possible injury.

It is relatively easy to census unobstructed stream areas. Where brush and boulders are abundant, however, the work progresses more

slowly and some fish are not recovered on the first trip over the section because they may drift under obstructions when stunned. Often they may be captured by another trip, since fish recover from the shock quickly. Four trips over the census area usually are required.

## Results

During the summer of 1939 it is proposed to compare the recovery of fish by electric shock, by seining and by chemical methods. At present no comparisons of the relative efficiency of the various methods can be made.

The electric-census method was tested on Crystal Creek, Lewis County, New York, selected as a typical New York stream. The creek is 20 to 30 feet wide, has an average depth of 15 inches and a flow of 40 cubic feet per second. Three sections, each 182 feet long, were sampled.

Section 1 extended downstream from the upstream side of a wooden bridge. The bottom was sandy except for a few boulders underneath the bridge. In general the cover was poor. This area would have been suitable for seining. The census required about one hour after the electric apparatus was set up.

Section 2 was situated at a bend in the stream. The main flow of water was near one bank, which provided good cover. Submerged logs and small snags, as well as some undercutting of the bank, made the section appear reasonably satisfactory for trout, but fairly difficult to seine. The census required two and one-half hours.

Section 3 appeared to be the best trout area of the three sections. The bottom was made up of rubble, bed rock, sand and a few boulders. There was a region of fast water, and three or four excellent pools and riffles. The scattered boulders offered excellent hiding places, as did a few logs near the shore line. Seining would have been impossible. The census required five hours.

About one hour was required to arrange the apparatus for each census, so that a total of two days was spent on the stream. Additional experience and improvement of technique should reduce the time required.

The following fishes were found in the stream:

Brown trout, *Salmo fario*
Brook trout, *Salvelinus fontinalis fontinalis*
Common sucker, *Catostomus commersonnii commersonnii*
Black-nosed dace, *Rhinichthys atratulus atratulus*
Horned dace, *Semotilus atromaculatus atromaculatus*
Long-nosed dace, *Rhinicthys cataractae*
Sculpin, *Cottus cognatus*

The sampling of the three sections was conducted on June 2 and 3, 1939. The results are shown in Table 1.

TABLE 1. SPECIES, NUMBER, LENGTH RANGE AND TOTAL WEIGHT OF FISH COLLECTED FROM THREE SECTIONS OF CRYSTAL CREEK, NEW YORK, BY MEANS OF ELECTRIC SHOCK, ON JUNE 2 AND 3, 1939.

| Section No. | Species | Number recovered | Length range (inches) | Total weight (ounces) |
|---|---|---|---|---|
| 1 | Brown trout | 2 | 3.75 to 4.25 | 0.9 |
| | Common sucker | 6 | 4.25 to 7.25 | 7.6 |
| | Black-nosed dace | 11 | 2.00 to 3.00 | 0.9 |
| | Horned dace | 3 | 2.25 to 2.63 | 0.2 |
| 2 | Brown trout | 8 | 4.00 to 9.50 | 17.0 |
| | Common sucker | 11 | 4.63 to 9.75 | 18.6 |
| | Black-nosed dace | 7 | 2.75 to 3.12 | 1.1 |
| | Horned dace | 2 | 4.00 to 6.00 | 2.1 |
| 3 | Brook trout | 1 | 4.50 | ? |
| | Brown trout | 33 | 3.75 to 11.50 | 62.6 |
| | Long-nosed dace | 14 | 3.37 to 6.25 | 12.0 |
| | Common sucker | 10 | 4.63 to 10.25 | 24.0 |
| | Sculpin | 1 | 4.50 | 0.8 |

During a second census of Section 3 on July 12 and 13 an attempt was made to determine the effectiveness of the electrical method. After the section had been blocked off, one trip was made over the area. The trout obtained were marked with jaw tags and the right pelvic fin was clipped from each of the other fish. All were then released in the test section and a period of two hours allowed to elapse. Two trips were then made, followed by another the next day. Results are shown in Table 2. Mechanical difficulties with the gasoline engine impaired its efficiency and undoubtedly reduced the number of fish collected in the last three trips.

TABLE 2. NUMBER OF FISH REMOVED AND MARKED FROM SECTION 3 OF CRYSTAL CREEK ON JULY 12, A.M. NUMBER AND PER CENT RECOVERED JULY 12, P.M., AND JULY 13, P.M., NUMBER OF MARKED FISH FOUND DEAD, AND PERCENTAGE RECOVERY

| Species | Number recovered and marked July 12, a.m. | Length (inches) | Number of marked fish recovered July 12, p.m., and July 13, p.m. | Number of marked fish found dead | Percentage recovery[1] |
|---|---|---|---|---|---|
| Brown trout | 19 | 2.31 to 10.19 | 15 | 1 | 83.5 |
| Brook trout | 1 | 7.62 | 0 | 1 | 0.0 |
| Common sucker | 7 | 5.75 to 10.62 | 5 | 1 | 83.3 |
| Sculpin | 1 | 3.75 | 1 | 0 | 100.0 |
| Long-nosed dace | 2 | 4.25 to 5.12 | 0 | 0 | 0.0 |
| Horned dace | 1 | 3.19 | 0 | 0 | 0.0 |
| Total | 31 | ...... ...... | 21 | 3 | 75.0 |

[1]Percentages were computed by dividing the number of marked fish recovered by the number tagged minus the number of dead fish recovered.

In cooperation with the New York State Biological Survey, an attempt was made to determine the relative efficiency of electric shock and seining, in Mill Stream (in the drainage of the Salmon River) near Redfield, New York. The flow of water is about 6 cubic feet per second, the average width of the stream 20 feet and the average depth

18 inches. The bottom is composed of rubble, "flagstone" boulders, bed rock and gravel. The tributary streams of the Salmon River are heavily fished early in the season so that on June 28, when the study was made, no legal trout were collected.

The fish recovered were:

Brook trout, *Salvelinus fontinalis fontinalis*
Rainbow trout, *Salmo gairdnerii irideus*
Fine-scaled sucker, *Catostomus catostomus*
Common shiner, *Notropis cornutus cornutus*
Long-nosed dace, *Rhinichthys cataractae*
Fan-tailed darter, *Catonatus flabellaris flabellaris*
Black-nosed minnow, *Notropis heterolepis*
Cut-lips minnow, *Exoglossum maxillingua*
Common sucker, *Catostomus commersonnii commersonnii*
Sculpin, *Cottus cognatus*
Black-nosed dace, *Rhinichthys atratulus atratulus*

The section selected for study was seined intensively for about three-quarters of an hour. The difficulty of seining among the boulders indicated that no more than a small part of the total population could be obtained by that method. Thirty-one fish were caught by the seine, and of these twenty-six were returned to the area after the right ventral fin had been clipped from each. A total of 176 fish was collected by the electrical method but of the marked fish only 38.5 per cent were recovered (Table 3).

**TABLE 3. NUMBER AND SIZE RANGE OF FISH COLLECTED BY SEINING IN MILL STREAM, TAGGED AND LIBERATED. NUMBER AND SIZE RANGE OF FISH, BOTH MARKED AND UNMARKED, COLLECTED BY THE ELECTRICAL METHOD**

| Species | Recovered by seining and marked | Recovered by electrical method | | Size range (inches) | Percentage recovery |
|---|---|---|---|---|---|
| | | Marked | Unmarked | | |
| Brook trout | 3 | 1 | 15 | 1.8 to 6.4 | 33 |
| Rainbow trout | [1]5 | ---- | 3 | 1.0 to 5.7 | ---- |
| Fine-scaled sucker | 0 | ---- | 1 | 8.0 | ---- |
| Common shiner | 0 | ---- | 2 | 4.7 to 4.9 | ---- |
| Long-nosed dace | 0 | ---- | 8 | 4.3 to 5.1 | ---- |
| Fan-tailed darter | 0 | ---- | 4 | 2.2 to 3.1 | ---- |
| Black-nosed minnow | 3 | 2 | 14 | 2.2 to 2.3 | 67 |
| Cut-lips minnow | 3 | 1 | 13 | 2.5 to 3.9 | 33 |
| Common sucker | 2 | 1 | 11 | 4.3 to 7.9 | 50 |
| Sculpin | 0 | ---- | 71 | 1.7 to 3.6 | ---- |
| Black-nosed dace | 15 | 5 | 24 | 2.0 to 3.2 | 33 |
| Total | [1]26 | 10 | 166 | ---- ---- | 38 |

[1]Five rainbow trout recovered by seining were not liberated.

The low percentage recovery of marked fish apparently was due to their small size which made them difficult to see after they had been stunned. It is concluded, therefore, that the electrical method as employed during the present study is much less effective in the capture of small fish than in collecting fish of legal length and larger, at least in rapid streams where many large stones are present.

Cold Spring Brook, Van Hornesville, New York, was surveyed with the electrical apparatus. This stream, unlike the others tested, has hard water. The results apparently were not affected by this condition. Another obstacle was encountered in this stream. An area having a muddy bottom and slow water became so roiled by the movement of the operators that visibility was reduced, making the collection of fish more difficult than in other streams tested.

Preliminary tests on the recovery of bass have been started, and indications are that they are easily stunned, perhaps more easily than trout.

## Literature Cited

Hager, Franz.
1934. Die Electrizität im Dienste der Wildbachfischerei. Österreich Fischereiwirtschaft, Nr. 7/8, Juli/August, 1934, S. 1-5.

McMillan, F. O.
1928. Electric Fish Screen. Bulletin of the Bureau of Fisheries, Vol. XLIV, 1928, pp. 97-128.

Needham, P. R., and John H. Rayner.
1939. The Experimental Stream, A Method for Study of Trout Planting Problems. Copeia, 1939, No. 1, pp. 31-38.

Shetter, David S.
1938. Review—Hager, Franz: Use of Electricity in Fishing Wild Streams. U. S. Bureau of Fisheries, Memorandum I-131, "The Progressive Fish Culturist," No. 36, pp. 32-33.

THE DECLINE OF THE PYRAMID LAKE FISHERY[1]

FRANCIS H. SUMNER

*Temporary Assistant, U. S. Bureau of Fisheries, Stanford University, California*

ABSTRACT

The history of the Pyramid Lake (Nevada) cutthroat trout (*Salmo henshawi* Gill and Jordan) fishery, conducted by reservation Indians, shows a rapid decline in the catch within the last few years. While the Indian is blamed for overfishing, the white man's demand for trout, the dams and diversions that he built along the Truckee River where the trout have spawned, the pollutants that he has dumped into the river, the spawn that he has taken, the competing species of fish that he has introduced, and principally the large amounts of water that he has diverted to another watershed, have led to a condition which has prevented the trout from reproducing its kind. The revival of the fishery is made doubtful by an agreement concerning the use of the Truckee River's flow, the expense of hatching and rearing a stock of the Pyramid Lake trout (not to mention the questionable availability of its eggs), and inadequate regulation of the fishery. Thus, the Pyramid Lake cutthroat trout fishery appears to be doomed.

INTRODUCTION

Pyramid Lake has, for many years, been associated in the mind of the angler with large trout. Lately, however, "fisherman's luck" on this body of water has not been very encouraging. What has happened to the monsters that formerly took a spinner so readily? This paper, which is an attempt at a reasonable explanation of this question, is the result of three months' field and laboratory work during the spring of 1938, under the auspices of the U. S. Bureau of Fisheries and the U. S. Indian Service.

Other studies in connection with the fisheries problems of Pyramid Lake were made by Prof. J. O. Snyder in 1911 and 1912 (Snyder, 1917), and by Mr. M. J. Madsen[2] in 1935.

Pyramid Lake lies about 30 miles by road northeast of Reno, Nevada, and is entirely within the Pyramid Lake Indian Reservation, which also includes about 25 miles of the lower Truckee River. The lake is about 27 miles long and about 11½ miles wide at its greatest width. The Truckee River, its only permanent inlet, reaches the southern end of the lake after flowing about 100 miles east and north from Lake Tahoe. Pyramid Lake has no outlet, and therefore its waters are becoming gradually more salty.

From the researches of Russell (1885), we learn that during the last ice age, Pyramid Lake was joined with its neighbor, Winnemucca Lake, and also with Walker, Carson, and Honey Lakes to form Lake Lahontan, which also covered present desert areas north to the Oregon

[1]Published with the permission of the Commissioner of Fisheries.
[2]A preliminary survey of Pyramid Lake, Nevada (unpublished).

line. It was during this period that the Tahoe and Pyramid cutthroat trout, *Salmo henshawi* Gill and Jordan, is assumed to have attained its present distribution.

## History of the Pyramid Lake Fishery

Before the coming of the white man, the cutthroat trout was one of the principal staples of the Paiute Indians resident at Pyramid Lake. During the spring spawning migrations up the Truckee River, as far even as the tributaries of Lake Tahoe, the thickly-crowded trout were easily captured. Friendly tribes, such as the Shoshones, were permitted to join in the fishing, while the enemy Modocs from the north made occasional raids on the fishing encampments.

The white man supplied a ready market for the trout that the Indian caught so easily, and thus the rise of the fishery began. A Biennial Report of the Nevada Fish and Game Commission related that in 1881, trout from the Truckee River were sold in Belmont, Nye County, for thirty-seven and one-half cents per pound; and a Report of the Commissioner of Indian Affairs stated that in 1884 more than 70,000 pounds of trout were shipped at an average price of six cents. For a great many years, one white man bought from the Indians and shipped regularly whole carloads of trout to city markets.

With the increased demand for the trout, more efficient ways of catching them were learned by the Indians from the white man. They learned to cast a spinner, to jerk a snag-line through the water, and even to tie a bent and sharpened piece of bed spring to a bamboo pole to make a gaff. Indians told the writer that angling was their preferred method of fishing in the river, as in the lake, until it became increasingly difficult to catch trout in that manner. It was said that 1920 was the last year in which hook-and-line fishing was good above the river-mouth, and a Nevada Biennial Report stated that in that year Indians were gaffing trout in the lower river. However, gaffing was introduced earlier, for in 1890 Indians were reported to be using "grab-hooks" to catch trout.

Between fifteen hundred and two thousand trout were taken during one day in March of 1926, and most of them were sold off the Reservation. Nevertheless, the fishery was headed for evil days, as the following facts indicate. It was reported that 1934 was the last year in which boat angling was good on the lake. In 1935, during the months of March, April, and May, 6,998 trout, averaging a little more than 10 pounds in estimated weight, were stamped so that they could be sold by their Indian owners. Many more fish must have been consumed on the Reservation. The fishery took a decided turn for the worse in 1938, when a total of only 1,069 trout was caught during the period, February 20 to May 15. One is immediately struck, moreover, by the 19-pound average of estimated weights for that year's catch, almost twice as much as the average weight in 1935. These averages were derived from weights estimated by Indian wardens who stamped trout

for sale. The writer weighed, with spring balances, 195 trout of the 1938 catch before they were cleaned, and obtained an average of 20 pounds, a value that agrees closely with the average estimated by the wardens. Very few small fish were taken, although formerly there was, according to the Indians, a well-marked run of younger cutthroat, called "tommy trout," which had its peak after that of the larger spawning fish. Evidently an older age group predominated in the 1938 catch.

This dominance of old fish can be more fully appreciated by referring to Figure 1, a length-frequency curve derived from measurements of 231 trout in the 1938 catch. Although we have no length-frequency data from former catches to compare with the present curve, enough information has been gathered to show that the present condition is not normal. Snyder (1917) recorded the measurements of twenty trout caught in Pyramid and Winnemucca Lakes in 1911 and 1912. The average weights of these fish—3.7 pounds[3]—and the average weights of trout in 1935 indicate that the normal spawning runs of cutthroat contained many more small fish in former years. The only possible conclusion is that reproduction of the species is probably

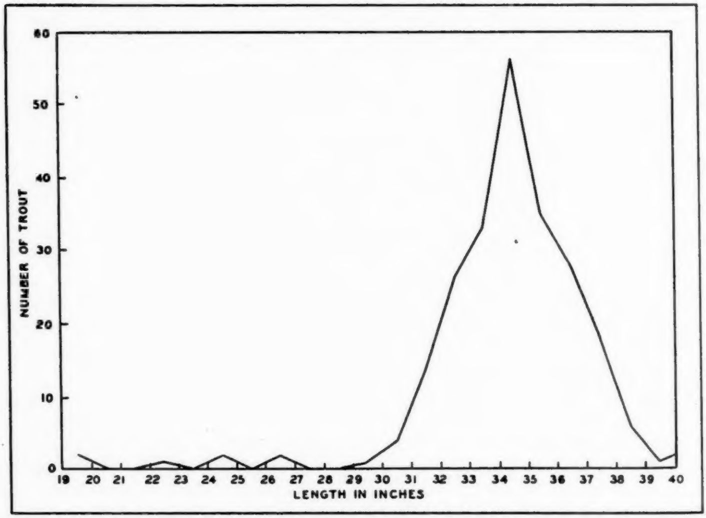


Figure 1.—Length-frequency curve for 231 Pyramid Lake cutthroat trout of the 1938 spawning run.

[3]It should be remembered that these fish, which were presumably caught by hook and line, were a sample of the entire populations of the lakes; not just of the spawning runs.

not taking place—at least not to an extent sufficient to maintain a normal proportion of young fish.

This assumption is strengthened by an examination of scales from the trout measured. Although these scales proved difficult to read and, according to Prof. J. O. Snyder, show a possible spawning-check absorption of one or two years' growth, they do indicate that most of the fish were of about the same age, and hence that the 1938 catch represents the remnant of one or two years' successful spawning. A median age of 6 or 7 years as read from the scales, plus a year or two for the correction of the possible absorption of the scales, would place this last successful spawning in about the year 1930, which year also happens to be the last in which spawn was taken from Pyramid Lake trout for hatching. The last spawning run of any consequence occurred in 1928 or 1929.

## Factors in the Decline of the Fishery

Over-fishing by the Indians is generally assumed to be the principal reason for the decline of the Pyramid Lake trout fishery.[4] On the other hand, not much attention has been given to certain features of the white man's activities which have been inimical to the trout.

One of his first activities that may be mentioned is the construction of dams across the Truckee River. H. G. Parker, Nevada's first Fish Commissioner, reported in 1878 on dams "so constructed that it was impossible for fish to ascend above them, for the purpose of spawning." Early settlers had raised many low rubble diversion dams along the river. These obstructions did not constitute serious barriers to trout migration when water spilled over them, but when the river was low, water percolated through the rubble and the fish were completely stopped. The Derby Dam, a concrete structure about 12 feet high, and located about 30 miles above the mouth of the river, was constructed in 1902. Fishways were urged for Truckee River dams in 1908, indicating that there may have been none in the Derby Dam for six years after its construction. Moreover, in 1912, its fishway was reported not to be working because of low water, with the consequent loss of tons of fish. The Pyramid Lake Indian Reservation Dam was constructed in 1917. It is a concrete structure about 10 feet high, located about 8 miles above the river-mouth. A good fish ladder forms an integral part of the dam. When the ladder was observed in 1938, flashboards prevented its operation. The explanation given was that no fish had reached that point for several years. A count of migrating trout was made at this dam in 1924. In thirteen hours, spread over a period of seven days, 1,240 trout entered the first pool in the fish ladder.

There are fourteen diversions along the Truckee River from the Derby Dam to the Pyramid Lake Indian Reservation Dam, twelve of

[4]Although older fish predominated in the 1938 catch, a depleted fishery usually shows the reverse condition with a dominance of small fish.

them being at low rubble dams. None of these diversions is screened, although one was said to have had a rotary screen ten years ago. Thus great numbers of young trout must have been lost in the fields during past years, as well as adults on their way back to the lake after spawning.

Pollution of the river has constituted another condition deleterious to the trout. For at least two decades, until about 1930, a paper mill at Floristan dumped into the Truckee River waste which, in 1913, killed fish in an experimental hatchery. Also, much sawdust was dumped in from sawmills and deposited in the river. The cities of Reno and Sparks ran their sewage into the river until about 1930, when sewage-disposal plants were constructed; and railroad shops at Sparks are said to have run waste oil into the river for years.

Another factor in reducing the supply of Pyramid Lake trout was the taking of spawn. Countless adult trout were killed by the Indians for their spawn alone, until within recent years it became illegal in California to angle with fresh spawn as bait. Fish-culturists have shared in the unfortunate proceedings also. Eggs were taken from Pyramid Lake trout during their spawning runs as early as 1889 or 1890, if not before. Many fry were planted back into the river, but records[5] show that for 6 years between 1919 and 1925, while 6,400,000 eggs were taken, only 1,719,000 fish were planted back into the stream.

Many of the eggs were shipped to other states, particularly California, in trade for species that were introduced into the Truckee River and Pyramid Lake. In 1889 or 1890, Sacramento perch, *Archoplites interruptus* (Girard), were introduced into the lake, and in 1907 or 1908, rainbow trout, *Salmo irideus* Gibbons, eastern brook trout, *Salvelinus fontinalis* (Mitchill), mackinaw trout, *Cristivomer namaycush* (Walbaum), and largemouth black bass, *Huro salmoides* (Lacépède), were planted into the Truckee River. "Royal Chinook" salmon, *Oncorhynchus tshawytscha* (Walbaum), were planted into both the river and the lake in 1909. The only other species recorded as introduced into the lake is the common carp, *Cyprinus carpio* Linnaeus, while the Truckee River has been stocked not only with the species above noted, but also with squaretail or bullhead catfish, *Ameiurus nebulosus* (LeSueur), silver salmon, *Oncorhynchus kisutch* (Walbaum), and Loch Leven or brown trout, *Salmo trutta* Linnaeus. It is impossible to estimate the effects of the competition of these exotic species on the native cutthroat trout, but the introductions have probably not been beneficial.

Perhaps the greatest single factor in the decline of the Pyramid Lake trout is the diversion of large amounts of Truckee River water at the Derby Dam to the Newlands Reclamation Project in the Carson River Basin. The average annual flow of the Truckee River since 1900, above all diversion, has been about 500,000 acre feet. Diversions,

---

[5]Biennial Reports of the Nevada Fish and Game Commission.

principally that at the Derby Dam, are estimated to have taken approximately 250,000 acre feet[6] annually of this total. The result of this process has been that the lake's surface elevation declined 53 feet between 1909 and 1938 (Figure 2), with the further consequence that the Truckee River has cut down near its mouth, washing out much fine gravel and sand from ancient Lake Lahontan deposits to form a flat, half-mile-wide delta.

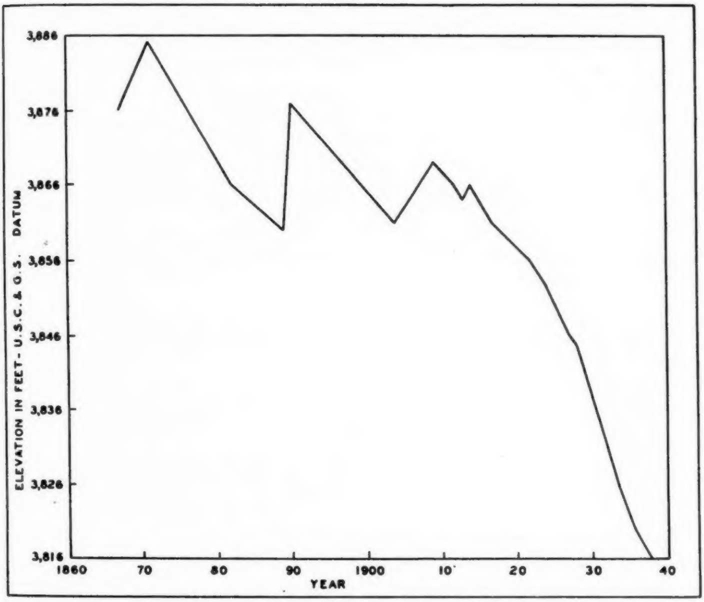


Figure 2.—Surface-level changes, Pyramid Lake, Nevada.

It should be said here that Pyramid Lake has not been the sole source of cutthroat spawning runs. Its neighbor, Winnemucca Lake, also matured many large trout which ran into the river through Winnemucca Slough. The river cut down below the head of the slough several years ago, preventing any more trout from ascending it to the river, and causing a rapid lowering of Winnemucca Lake. It was expected that this lake would go completely dry last summer (1938). Its fish population is said to have died off suddenly in the early 1930's.

[6]Data supplied by Mr. George Hardman, Nevada State Coordinator, U. S. Soil Conservation Service.

The delta of the Truckee River at Pyramid Lake appears to have been relatively impassable to trout for the last several years. Indians claim that in about 1924, they picked up about 300 trout which were trapped by shifting sandbars on the delta, and in succeeding years, many fish were reported to have become stranded and to have had their eyes picked out by gulls. Moreover, when the Nevada Fish and Game Commission attempted to take spawn at the Pyramid Lake Indian Reservation Dam in 1926, it was found that no fish could surmount the bar at the river's mouth. Conditions must have become increasingly worse, for, although spawn was taken at the dam in 1928 and possibly in 1929, the U. S. Bureau of Fisheries representatives used dip-nets at the edge of the delta in 1930 to catch trout for spawning. The writer, during his 1938 visit to the lake, saw trout floundering helplessly in shallow channels, and one was seen completely out of the water, flopping about on a sandbar.

Earlier in this paper it was said that no run of trout was noted at the mouth of the river this year (1939). However, it has been reported to the writer that cui-ui, *Chasmistes cujus* Cope, ran up to Nixon, about 6 miles above the lake. That these sucker-like fish were able to cross the delta for the first time in years may be accounted for by the extreme low water in the river following a winter of light snowfall. Evidently diminished volume, correlated with a slower flow of the river, allowed the fish to make headway against the current, which has been too rapid for them in late years. That no run of trout was noticed in this, an evidently favorable year, is a good indication of their present scarcity.

## Can the Pyramid Lake Trout Fishery Be Revived?

Several factors operate against a revival of the Pyramid Lake trout fishery. First, the Truckee River Agreement[7] of 1935 makes no provision as to the amount of water that shall be allowed to flow into Pyramid Lake. Second, it has been determined that the cost of a hatchery and rearing ponds would not be justified on the basis of the market values of the trout, even if eggs could be obtained readily without buying them outside the state. Third, there is the difficulty of regulating the fishery. The Constitution and By-laws of the Pyramid Lake Paiute Tribe, approved by the Secretary of the Interior on January 15, 1936, does not bind the Indians to respect county or state laws. The Tribal Council did set up fishing regulations for 1935 and 1938, but it is noteworthy that for resident Indians, no limit was placed upon the catch.

The question may be interposed here that, in view of the fate which overtook Winnemucca Lake, previously mentioned, and since Pyramid Lake similarly is characterized by an increasing concentration of its dissolved solids, are not its fish doomed anyway? Yes, but probably

[7]An agreement between the Federal Government and individual users of Truckee River water concerning the apportioning of the river's flow.

not before a long period of time. At the present rate of subsidence and inflow, it would require eighty years for Pyramid Lake to be reduced to one-fourth of its present volume, at which time it would attain stability with respect to inflow and evaporation. In such an eventuality, the dissolved solids would be increased from approximately 4,300 p.p.m. to about 14,000 p.p.m., or less than half the concentration of sea water. Since coast steelhead cutthroat trout, *Salmo clarkii* Richardson, mature in the ocean, it is probable that Pyramid Lake cutthroat trout could accustom themselves to a gradually increasing salinity approaching that of the ocean.

## Conclusion

It appears then, on the basis of present data, that the Pyramid Lake cutthroat trout is doomed as far as its economic and angling values are concerned. There will probably continue to be some trout in the lake as the result of spawning by fish resident in the river, but there will no longer be the hordes which formerly ascended the river to spawn. The blame for this eventuality, if blame there must be, rests on the white man. The rise of the fishery coincided with his coming to the West, and his subsequent activities have contributed heavily to its decline.

## Summary

1. A brief history of the Pyramid Lake cutthroat trout fishery is given, including catch records for two recent years.

2. Factors in the decline of the Pyramid Lake fishery are discussed. They indicate that the white man, and not the Indian, has been primarily responsible for the present scarcity of trout.

3. Factors militating against a revival of the fishery are discussed.

4. It is concluded that the Pyramid Lake cutthroat trout, as an economic entity and angling attraction, is doomed.

## Literature Cited

Russell, Israel Cook.
1885. Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada. Monographs of the U. S. Geological Survey, Vol. 11, pp. 1-288.

Snyder, John Otterbein.
1917. The fishes of the Lahontan system of Nevada and northeastern California. Bulletin of the U. S. Bureau of Fisheries, Vol. 35, pp. 33-86.

---

## Discussion

Mr. R. G. Parvin: You say that this lake is becoming salty?

Dr. Osgood Smith: Alkaline might be the better word for it. It is a desiccating lake; the water is coming in and evaporating. It does not taste salty.

Mr. Leo Shapovalov: You have no data on *Salmo smaragdus?*

DR. SMITH: No.

MR. SHAPOVALOV: You have not seen any specimens that you recognized?

DR. SMITH: No.

THE PRESIDENT: In Pyramid Lake in recent years we have seen an important fishery not only decline but almost reach the point of extinction, through the diversion of water to other purposes and through man's greed. We have seen an interesting biological change take place whereby we can more easily understand the creation of such waters as Great Salt Lake. The picture is even darker, I personally believe, than the author indicates. Small fish from hatcheries, liberated in the lake even as far back as eight years ago, turned over and died as if they had been placed in a vinegar bath. The question arises in my mind whether even with the careful and gradual addition of lake water to the waters in which the fish were reared it would be possible to acclimatize the young fish to the waters of Pyramid Lake at this time. Pyramid Lake produced what is probably the largest native trout that has been known—41 pounds. We have the last one of America's outstanding trout-producing waters, unique in many respects, in Pyramid Lake.

# PLACER MINING SILT AND ITS RELATION TO SALMON AND TROUT ON THE PACIFIC COAST[1]

Osgood R. Smith

*U. S. Bureau of Fisheries, Stanford University, California*

Abstract

Renewed activity in the placer gold mining country of the Pacific Coast States has raised the question of how much harm silt does to salmon and trout. The effect silt may have on migrating adult fish, on the selection of spawning places, and on the survival of fish food, is discussed. The conclusion is drawn that silt, whether from placer mining or natural erosion, is harmful to salmon and trout if it is heavy enough to form a layer on the stream bottom or if it persists during periods between floods.

During the last few years the high price of gold has caused a boom in the placer mining country of the West, and many neglected bars and high gravel deposits are again being washed for gold. On the American and Yuba Rivers of California high dams are being built to serve as catch basins for hydraulic mining debris and thereby legalize the resumption of operations in those rivers without endangering farms or navigable streams below.

This increased activity has revived an old quarrel between sportsmen and miners regarding the effect of silt on fish. Biologists, hatchery men, and sportsmen believe that silt is harmful to both fish and their eggs. Those interested in hydraulic placer mining, which washes great quantities of silt into the streams, generally have taken the opposite view, and they have presented convincing evidence to support their views. Contradictory reports have also appeared in print and consequently both sides have been able to quote "authorities." In view of the conflicting opinions as to the effect of muddy water on fish, it seems advisable to review the known facts in the case. It appears that both miners and sportsmen are partly right.

The miners have some very good reasons for believing that the silt and mud from placer operations do not harm fish. One of the stock reasons is that in the early pioneer days in California many streams carried very heavy loads of silt, yet the salmon and steelhead were known to come up through it. The greatest decline in the numbers of salmon and trout, there is reason to believe, came during the turn of the century or later—after the period of most extensive placer mining.

This evidence becomes less convincing, however, when we stop to analyze it. In the first place, no actual figures are available which give any estimate of the size of any salmon or steelhead run before the mining started. Also, the commercial and sport fishing was not intense enough in the early days either to deplete a stream or to serve as a

[1]Published with the permission of the Commissioner of Fisheries.

means of measuring a decline in numbers of fish. The runs may well have been reduced 30 per cent or more and still remained large enough to be noticeable to miners working in the streams. It is well known that salmon and trout will go up through muddy water, but there is also good evidence that the most successful spawning occurs in clear water. It is quite likely that most of the salmon and trout coming up through waters heavily polluted with mining silt in the old days found clear tributaries above and that the eggs laid there maintained the runs. This is exactly what the sockeye salmon do in some Alaskan streams under natural conditions.

F. A. Davidson, U. S. Bureau of Fisheries, recently showed colored motion pictures of salmon streams in the Bristol Bay area, Alaska, which carried a load of glacial silt as bad as or worse than that produced by hydraulic mining. He said that the salmon swam up through this silt but that they always spawned in the clear tributaries.

Additional evidence that salmon and trout will spawn in clear rather than muddy water, if they have a choice, was brought out during a recent survey of the Yuba and American Rivers in California (Sumner and Smith).[2] The chinook salmon, *Oncorhynchus tschawytscha,* in this instance did not have a chance to go above the silt area because their way was blocked by the Daguerre Point Dam on the Yuba River, but a clear stream entering just above the dam produced a streak of clear water along one side of the wide, shallow river. The remainder of the river was muddy most of the time because of the many small gold-washing operations but the silt from these operations was not heavy enough to form a noticeable coat or blanket over the stream bed. In general, the bottom conditions and the current were about equally suitable for spawning in the clear and muddy parts of the river. Several salmon were seen digging redds in the muddy water but they were isolated individuals widely scattered over the available space. In the clear water, however, the salmon were concentrated and the redds were dug so close together that they overlapped and were dug up by females spawning later. This overlapping was demonstrated on January 19, 1939, when Sumner dug into a redd and found both eyed eggs and yolk-sac fry very near the surface. Eggs in such widely separated stages of development taken from one redd indicate that spawning occurred at least twice in the same place. Local residents also reported that they saw salmon congregated in the clear streak of water in other years. Additional streaks of clear water enter the river a mile or so below the dam where water seeps out through dredger gravel piles. Here again salmon were attracted in more conspicuous numbers than they were to nearby spawning areas in the main river. Unfortunately for the salmon, the poachers also have noticed that the fish congregated in these small, clear streams. In view of these observations that salmon

[2]Sumner, F. H., and Osgood R. Smith. A biological study of the effect of mining debris dams and hydraulic mining on fish life in the Yuba and American Rivers in California. (Unpublished.)

select clear water for spawning, it cannot possibly be assumed that silt is harmless because salmon will migrate through heavy silt. It may not stop the migrations, but it does limit the spawning areas.

It is true that most salmon and steelhead trout streams carry a great deal of natural silt during flood stages, even in sections where spawning occurs. This has often been cited as proof that silt from hydraulic mining, which is, after all, only unpolluted soil and gravel, does not harm fish. This evidence also is not as conclusive as it seems. Good streams are clear most of the time, or at least during spawning periods, and streams which are always silty seldom have large populations of salmon or trout, even though the silt may come from natural erosion. The Sacramento River of California and its tributaries, for instance, often are very muddy, but the salmon spawn in them when the upper reaches are clear.

Fishermen may complain that muddy water spoils the fishing, although the fish may be plentiful but not biting. The silt actually may protect the fish and, temporarily at least, do more good than harm.

Ward (1938a, 1938b) in his study of the effect of placer mining on fish in the Rogue River, Oregon, concluded that such mining has not done any harm in that river. He limited his discussion to the one river, bringing out such points as "The spawning grounds lie chiefly at least above the region in which placer mining run-off is poured into the stream" and the observation that the turbidity derived from placer mining did not seem to increase that resulting from natural erosion. Despite the fact that Ward's conclusion was qualified and was applicable to but one stream, his paper has been cited as proof that in general mining silt is not harmful.

Even on the Rogue River, the evidence that placer mining has not been harmful is unconvincing. Salmon spawn in the Sacramento River, California, and in other rivers on gravel bars which are very similar to and fully as large as those which Ward illustrated and said are not used for spawning. One cannot help but wonder if these places might not have been used for spawning before the placer mining was started. Also, Ward's findings do not agree entirely with those of Ellis[3] and assistants, who made a careful biological and chemical survey of the Rogue River. During that survey the amount of silt was determined with light penetration instruments and a large series of samples was taken of bottom food organisms. Ward relied on general observations. Ellis found that the silting in the Rogue River was not very heavy, and that it did not seem to affect the best spawning areas. However, he did find that "in portions of these tributaries of Rogue River where the stream bottom showed definite silting, the bottom fauna and available fish food were correspondingly reduced." These reductions amounted to from 25 to 50 per cent. He concluded that the Rogue River is beginning to suffer from silt deposition and that continued

[3]Ellis, M. M. Report on the stream pollution investigations of the Rogue River by the U. S. Bureau of Fisheries, August, 1937. (Unpublished.)

introduction of soil washings will cause conditions to become progressively more unfavorable for salmonid fishes. It would seem that the Rogue River represents somewhat of a borderline case in so far as silt damage is concerned.

Griffin, in Appendix B to Ward's report (1938a), gave the results of an experiment which seems to prove, according to the California Mining Journal, October, 1938, that "young fish thrive on mud." In those experiments, cutthroat trout and chinook salmon fingerlings were held in hatchery troughs, some containing clear water and others muddy water. In both species, the survival was greater in muddy than in clear water. However, in each of the two tanks of clear water, the heaviest loss occurred during the first four days of the experiment. Griffin attributed the heavy loss to the fact that the fish in clear water were able to see better and were so frightened by activity near the tanks that they dashed against the walls and injured themselves. Whatever the cause, a mortality as large as forty-six out of seventy-five salmon fingerlings in four days must be attributed to some unusual factor which would not affect wild fish. In fact, ten of the forty-six fingerlings died because they leaped out of the tank. Consequently it would be better to compare survivals after the fourth day. When this is done it appears that the salmon mortality was higher in muddy water, 12.2 per cent, than in clear water, 6.9 per cent. Results of the experiments with the cutthroat trout were the reverse; mortality was 42.9 per cent in muddy water and 85.7 per cent in clear water, disregarding losses during the first four days. Both percentages of mortality for cutthroat trout are so abnormally high and the number of fish used in the experiment so small (fifty and forty at the start) that the difference between the percentages has no significance. The only conclusion that may be drawn from the two experiments is that salmon and trout fingerlings can survive and take food for a few weeks in muddy water. Griffin himself stated practically the same thing, but unfortunately he presented his data in such a way that they can be misinterpreted easily. Incidentally, the fact that fish can find artificial food in muddy water would not help them much in streams where silt has smothered the natural food organisms.

Concerning the effect of fine silt on eggs, nothing can be deduced from Griffin's experiment. Hobbs (1937) found that in New Zealand streams the mortality of trout eggs was greatest in redds that contained the largest proportion of fine materials (under 0.03 inch in diameter). Shapovalov (1937) also concluded, from experiments with steelhead eggs, that silting can be detrimental to the survival of eggs in the gravel. Ward (1938a) stated: "Erosion silt in some streams has been found to cover nests and spawning grounds with a blanket such that the bottom fauna was killed and eggs also suffocated in nests," while Ellis (1937, p. 394) remarked: "Parts of some streams, as the Yellowstone and Missouri—draining areas in which natural erosion has been proceeding rapidly—have been muddy with their loads of

erosion silt since before the earliest records by man and have as a result limited fish faunae.'' Undoubtedly the amount of silt is an important factor. There can be no doubt that placer mining silt, when fairly heavy, will smother salmon and trout eggs. Where the silt is very heavy it may even fill in the pools completely. On the Yuba River near Washington, California, to cite one example, a pool was seen that was completely filled in with fine silt so that there was no place left for a fish to hide. When that condition is manifested by long stretches of a stream it is difficult to understand how game fish can survive.

A survey of the Klamath River, California (Taft and Shapovalov, 1935), where hydraulic mines were being operated, revealed that ''Whenever a series of quantitative bottom samples was taken in one stream or in a series of similar streams during the summer, the average number of food organisms in the one square-foot samples was *always* less in mined areas than in non-mined areas.'' On the Scott River the investigators took three square-foot samples above and three below the mouth of a small tributary which brought in a heavy load of silt from a hydraulic mine. The samples from the silted areas averaged 36 organisms per square foot, whereas those from the clean bottom above averaged 249 organisms per square foot.

A similar situation was found on the American and Yuba Rivers of California by Sumner and Smith (footnote, p. 226). The silted areas in tributaries of the Yuba River were only 63 per cent as rich in food organisms as the unsilted areas, and in tributaries of the American River the silted areas were only 41 per cent as rich as the unsilted areas. These percentages are based on 336 square-foot bottom samples from the Yuba drainage and 312 from the American. These are field observations, not controlled experiments, but we do have definite experimental evidence that silt is injurious to fresh-water mussels. Ellis (1936) experimented with several species and found that ''layers of fine silt from one-fourth of an inch to one inch thick produced a high mortality among fresh-water mussels living in gravel or sand beds and in water which was otherwise favorable.'' Because Ellis used over 2,000 individuals in his experiments his results appear to be very conclusive.

From the above discussion it seems safe to conclude that a heavy load of silt in a stream is harmful to salmon and trout. Both young and old fish can stand a considerable amount of silt for several weeks, but the silt nevertheless may limit, or entirely prevent, successful reproduction and certainly limits the food supply. This conclusion applies either to natural erosion silt or to silt from hydraulic mines. The amount of harm done to salmon or trout will of course depend both upon the amount of silt in a stream and its persistence. We have no accurate measure either of the amounts of silt which salmonids can tolerate or of the length of time that salmonids can withstand heavily silted conditions, but we may assume that silt may be harmful if it is

heavy enough to form a noticeable deposit on the rocks and if heavy muddiness persists during periods between floods.

This paper is not an attempt to prove that all hydraulic gold mining must be prohibited because it is harmful to fish. However, it should be known and recognized that continued silting of streams is detrimental to game fish, or at least to their reproduction and food supply, and this undesirable condition should be balanced against the public benefits resulting from hydraulic mining.

## Literature Cited

Ellis, M. M.

1936. Erosion silt as a factor in aquatic environments. Ecology, Vol. 17, pp. 29-42.

1937. Detection and measurement of stream pollution. Bull. U. S. Bureau of Fisheries, Vol. XLVIII, No. 22, pp. 365-437.

Griffin, L. E.

1938. Experiments on tolerance of young trout and salmon for suspended sediment in water. Bull. Oregon Dept. Geology and Mineral Industries, No. 10, Appendix B, pp. 28-30.

Hobbs, Derisley F.

1937. Natural reproduction of quinnat salmon, brown, and rainbow trout in certain New Zealand waters. Fisheries Bull. N. Z. Marine Dept., No. 6, pp. 7-98.

Shapovalov, Leo.

1937. Experiments in hatching steelhead eggs in gravel. California Fish and Game, Vol. 23, No. 3, pp. 208-214.

Taft, A. C., and Leo Shapovalov.

1935. A biological survey of streams and lakes in the Klamath and Shasta National Forests of California. U. S. Bureau of Fisheries. Feb., 1935, pp. 1-63. (Mimeographed.)

Ward, Henry B.

1938a. Placer mining on the Rogue River, Oregon, in its relation to fish and fishing in that stream. Bull. Oregon Dept. of Geology and Mineral Industries, No. 10, pp. 3-31.

1938b. Placer mining and the anadromous fish of the Rogue River. Science, Vol. 88, No. 2289, pp. 441-443.

---

## Discussion

The Chairman: I have observed to my surprise that some of the most successful hatches came from bass nests wherein the eggs were pretty well smothered with silt; on the other hand, some nests in the same ponds that were quite clear failed to produce fry. Of course some nests filled with silt failed to yield a very good hatch. If only the nests where there was silt failed to produce fry, it might be concluded that the silt was responsible. Do you have any evidence of particular batches of eggs that have been killed by the silt?

Dr. Osgood Smith: None other than the cases I have reported. In reporting on the hatching of eggs in gravel Mr. Shapovalov stated that the silt did kill the eggs.

# A METHOD OF ESTIMATING THE NUMBER OF FISH IN A GIVEN SECTION OF A STREAM[1]

Daniel R. Embody

*Laboratory of Limnology and Fisheries, Cornell University, Ithaca, New York*

Abstract

**A method of measuring the areas of stream sections and a method of removing the fish therefrom are described. Cresol is used to render the fish helpless, and a formula is given for calculating the amount necessary for a treatment. The advantage of the new method lies in the fact that the fish can be removed from the stream, examined, and returned to the stream unharmed.**

## Introduction

In recent years, owing to the increased demand for better fishing in streams, the emphasis in fisheries investigations has shifted from the study of natural history and taxonomic problems to the study of production problems. The main object of these production studies is to obtain the information necessary to manage stream fisheries so that the water may be farmed to the fullest extent. In order to study fish production, however, methods of estimating the stock of fish on hand are needed. Various attempts have already been made to evaluate the stock of fish on hand. Embody (1929) in one of the early studies of fish populations captured the fish in a section of stream by suddenly diverting the water to another channel. Other methods consisted of seining areas of stream (Hoover, 1938); pumping sections dry (Needham and Rayner, 1939) and treating areas of stream with chemicals (unpublished data of G. C. Embody). The purpose of the present paper is to describe an improved method of determining the number of fish in a given section of stream which determination in turn may be used to estimate the total population of the stream.

In many instances streams are so large that it is physically and economically impossible to count the whole fish population. In such situations the only way in which a representative picture of the number of fish may be obtained is by sampling certain parts of the stream and using these data to estimate the whole population. Before the most efficient size of sample or the most efficient number of samples necessary to estimate the fish population of the whole stream can be determined, a method of measuring the area from which the samples are drawn and a method of securing the fish must be available. It is proposed, therefore, to describe a method of estimating the area of a

[1]This paper has been written from uncompleted manuscripts of the late Dr. George C. Embody—the father of the author. All facts pertaining to this method were obtained under the direction of Dr. Embody at the Laboratory of Limnology and Fisheries, Cornell University.

section or "sample" of stream, and a method of removing the fish therefrom for counting.

### Measuring the Area of a Section of Stream

The method of obtaining stream surface area given in this paper consists of multiplying the length not by the width but by the *mean* width. The length value is obtained by measuring along the bank of the stream with a tape the distance between the lower and the upper boundaries which are staked off. The error involved in measuring the length is so small that it may be neglected. The method of obtaining the mean width and its error was described fully by Embody, Goodrum, and Edmund (1938). This method consists of determining the width at regularly spaced intervals along the entire section. The number of measurements is determined by the variability of the width of the stream and the degree of accuracy desired. It is an interesting fact that on the rubble-bottom stream in New Hampshire described by those authors it was found that about 256 measurements were necessary to obtain a mean width with limits of accuracy not greater than $\pm$ 5 per cent (twice the coefficient of variation).

It must be remembered that when various measurements such as length and width are combined mathematically to produce a numerical value such as the area, the errors of each measurement combine to form a larger error for the final value. Therefore, when the number of fish per unit area is determined for a section of stream, that estimate of population density can be no more accurate than the estimate of the area itself. It can be shown further that when several sections of stream are combined to form an estimate of the total fish population, the errors of each sample also cumulate. The accuracy of calculated measurements, therefore, must be watched carefully. It is suggested that whenever a highly variable measurement, such as the mean width of a stream, must be made, definite steps be taken to control the measurements in such a way that the final values fall within the desired limits of accuracy. In this paper the word "error" is used in the statistical sense only. It has been shown that regardless of the magnitude of errors of individual observations such as single width measurements, the standard error of the mean of these values will become smaller as the number of observations is made larger (Fisher, 1936). The taking of all data should be governed by these principles.

To insure that the mean width and subsequent estimated area lie within the desired range of accuracy a preliminary estimate of the error may be made. Such a preliminary step could consist of measuring the stream width thirty times at regularly spaced intervals. From these measurements the coefficient of variation of a single width measurement may be estimated roughly and, with only a rough estimate of the coefficient of variation, the approximate number of measurements that must be taken for any degree of accuracy that may be desired can be computed easily by standard statistical methods (Fisher, 1936) or

from the table given by Embody, Goodrum, and Edmund (1938). Thus it may be concluded that by a simple preliminary step the element of doubtful accuracy has been removed from the data before the worker leaves the field.

## SECURING THE FISH FROM A SECTION OF STREAM

The first step in securing the fish from a section of stream by the chemical method is to render the fish helpless. Some chemical methods involve killing the fish, but the essential value of the present method lies in the fact that the fish can be removed from the stream, counted and returned to the water unharmed. The drug, cresol, is used to make the fish helpless. When fish are placed in a solution of cresol and water in an aquarium they turn over quickly and become helpless, but do not die. If they are removed to fresh water fairly soon they recover. The concentrations that will cause this phenomenon are so small that it is economically possible to apply cresol to streams of considerable volume. Preliminary investigations have shown that temperature and the volume of water flow are important factors affecting the efficiency of the drug. The effects of these factors must be evaluated in order to calculate the proper concentration to use.

In treating a stream, it has been found that the best results usually can be obtained when the quantity of cresol added is so adjusted that most of the fish will turn over within three to four minutes. The proper concentrations of cresol necessary to render fish helpless at different temperatures can be found most readily by experiments in the laboratory. From preliminary experiments of this nature (G. C. Embody, unpublished data) it has been found that for commercial cresol[2] (obtainable at any drug store) a solution of 1 part in 30,000 parts of water by volume will render most stream fishes helpless in three to four minutes if the temperature is between 55° F and 60° F. At lower temperatures the time is greater; at higher temperatures less time is required.

To obtain a solution of 1 part cresol to 30,000 parts of water in the stream it is necessary to know the volume of water flow. In small streams not over 4 feet wide and having a flow of less than 1,000 gallons per minute, the rate of flow may be measured conveniently with a folding, portable weir. Weirs and their use are fully described by Steward (1922) and Schroder and Dawson (1934). In larger streams, however, it is advisable to use the improved float-bob method (Embody, 1938). With the flow of water known it is a relatively simple matter to calculate the quantity of cresol that must be added to the stream within a certain period of time. The following formula may simplify the calculations:

$X = K\,F\,T\,C.$

$X =$ the number of cubic centimeters of cresol to be added.

---

[2]*Liquor cresolis compositus*—U. S. Dispensatory 21st edition, p. 628.

$K = 3{,}785.4$ (the number of cubic centimeters in a gallon).
$F =$ the volume of water flow in gallons per minute.
$T =$ the time in minutes necessary to render the fish helpless.
$C =$ the concentration of cresol desired in the stream, *e. g.*, 1:30,000.

The second step in determining the number of fish in a section of stream by the chemical method is to collect the fish after they have been rendered helpless. Preparations for this step must be made before the cresol is added. The upper and lower boundaries of the section are blocked off by nets or seines to prevent escape. A few large tubs of fresh water should be placed at regular intervals along the banks of the section, and collectors must be stationed to remove the fish to fresh water as soon as they turn over. Care must be exercised while the fish are out of the stream to prevent warming of the water and overcrowding in the tubs.

To add the cresol to the stream—the correct amount must be measured out and diluted with water until sufficient bulk is provided to make the solution easy to handle. This aqueous solution is then poured into the stream from a sprinkling pot. The rate of addition must be adjusted so that all the cresol will be added in the correct time (T of the formula). Furthermore, the entire width of the stream must be treated to insure thorough mixing. As a rule when cresol is added to the water (G. C. Embody, unpublished data) many fish begin to move downstream whereas others are caught in the treated water and become helpless in a few minutes. A few others will swim about with great vigor only to succumb eventually to the effects of the drug. Still others may dart under banks, under logs and even jump out of water and become stranded. The crayfish swarm from beneath the stones and mingle with the fish. The insects are paralyzed but appear to recover soon after the drug has become diluted.

As soon as the chemical is added to the water some of the fish begin to turn over. These fish must be removed immediately and placed in the fresh water in the tubs. Not only the fish that float against the lower blocking net but those caught under the banks and logs and those stranded must be removed. Each collector must patrol his section constantly to prevent the death of some of the weaker fish from an overdose. It is often advisable, when the water has become diluted sufficiently, to place the fish back in the stream in screen baskets.

## Summary of Instructions

In the foregoing paragraphs, the various details and special procedures necessary to use the described method of population study have been discussed. The various steps involved may be summarized as follows:

1. The section to be studied is first blocked off from the rest of the stream. Usually nets are set at the upper and lower boundaries and across all tributaries.

2. The volume of water flow is measured by a weir or by the improved float-bob method. Care must be taken in this determination to see that the volume of flow is representative of the stream. Where doubt exists, especially in long sections, several determinations must be made and the standard error computed.

3. From the time required for the fish to become helpless and the volume of water flow, the dosage is estimated by formula given on page 233.

4. The correct quantity of cresol to be added is measured and mixed with enough water to make the solution easily handled. The solution is applied to the stream from a sprinkling pot as evenly as possible from shore to shore. The rate of application should be adjusted so that the full amount of cresol will be added in time (T)—see the formula on p. 233. In some situations it may be desirable to introduce a second and a third dose after a five- or ten-minute interval as a check to insure the collection of all fish.

5. The helpless fish are removed from the stream by hand and placed in tubs of fresh water. One should look along the banks and pry under any shelter for those few individuals which in their excitement have sought such refuges. Since the fish are very weak they must not be overcrowded or permitted to remain in warm water.

6. After the fish have been removed the measurements of width and length may be made and the area computed without causing any undue disturbance to the stream. (Note the fact that this step is placed last.)

In conclusion it must be emphasized that this method of population study is only a tool for comparing fish populations. It provides a "yardstick" for comparing fluctuations in the abundance of fish in streams as correlated with such biological factors as the abundance of food organisms, pollution, and predation, and such physical or chemical factors as stream improvement, floods, temperature, and concentrations of dissolved gases. It should be mentioned also that although this method makes it possible to measure the population of a stream section, no statement can be made as to the size of the section that must be used or the number of sections that must be sampled to represent a stream adequately. These are problems that must be answered before extensive populations, so large that they must be sampled, can be studied.

## Literature Cited

Embody, George C.

1929. Stocking policy for the streams, lakes and ponds of the Erie-Niagara Watershed, exclusive of Lake Erie. A Biological Survey of the Erie-Niagara System; Suppl. 18th Ann. Rept. (1928) State of N. Y. Cons. Dept., pp. 23-24.

1938. Measuring the rate of flow in streams. Laboratory and Field Studies, Fish Culture No. 74, N. Y. State College of Agriculture, pp. 1-3. (Mimeographed.)

Embody, Daniel R., Clyde A. Goodrum and Stuart D. Edmund.
1938. A statistical analysis of width measurements on a New Hampshire stream. Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Department, pp. 198-200.

Fisher, R. A.
1936. Statistical methods for research workers. Oliver and Boyd, London and Edinburgh, pp. 120-175.

Hoover, Earl E.
1938. Fish populations of primitive brook trout streams of northern New Hampshire. Trans. Third North American Wildlife Conference, pp. 486-496.

Needham, P. R., and H. John Rayner.
1939. The experimental stream, a method for study of trout planting problems. Copeia, 1939, No. 1, pp. 31-38.

Schroder, Ernest W., and Francis M. Dawson.
1934. Hydraulics. Second edition, fifth impression. McGraw-Hill Book Co., Inc., New York and London, pp. 160-180.

Steward, W. C.
1922. The measurement of water. University of Idaho. Agr. Exp. Sta. Bull. No. 127, pp. 1-16.

# A STUDY OF THE NATURAL PROPAGATION OF THE PINK SALMON, *ONCORHYNCHUS GORBUSCHA*, IN BRITISH COLUMBIA

ANDREW L. PRITCHARD

*Fisheries Research Board of Canada, Nanaimo, B. C.*

ABSTRACT

From 1930 until 1939 a study of the natural propagation of the pink salmon (*Oncorhynchus gorbuscha*) has been carried out at McClinton Creek, a tributary to Masset Inlet on the Queen Charlotte Islands in northern British Columbia. This stream, approximately 4 miles in length, possesses a good spawning bed, and has always had a considerable run of pink salmon. Specially constructed fences were used to assess and examine the adults migrating upstream and the fry returning to the sea. The production of fry from five spawnings has varied from 6.9 to 23.8 per cent of the possible egg deposition, i.e., the number of eggs calculated to be contained in all the females released above the weir. The loss of 76.2 to 93.1 per cent may be due to many factors, among the most important of which are the climatic conditions as they affect the water height, velocity, etc., during the stages from spawning to fry migration, and predators as they prey upon the adult salmon, the eggs and the fry. It is suggested that the number of fish or the number of eggs deposited may have an effect on the production efficiency. Data on the marine portion of the life history will not be discussed until further information is obtained on the migrations in the sea.

---

The present paper is a brief resumé of pertinent data obtained through a long-term experiment to investigate the natural propagation of the pink salmon (*Oncorhynchus gorbuscha*). The study has been carried out on McClinton Creek, tributary to Masset Inlet on the Queen Charlotte Islands in northern British Columbia, and has covered a period of almost ten years, 1930 to 1939. The stream, approximately 4 miles in length, takes its source from springs in the mountains, the highest of which is about 2,800 feet. Like many coastal rivers, it is subject to considerable fluctuation in volume which may be directly correlated with the precipitation. The portion of the stream bed utilized by the pink salmon for spawning consists of small stones and gravel and extends about 2.5 miles above tidal influence. Beyond this more boulders and stones occur. The river gains elevation and loses size quickly until at its source it is little more than a small trickle.

As far as can be discovered, McClinton Creek has always had a considerable run of pink salmon which has varied from 10,000 to 155,000 individuals throughout the period of the investigation. The size of both the stream and its salmon run thus made it eminently suitable for observations on the natural propagation of the species.

In order to obtain counts of both the adults proceeding upstream and the fry migrating downstream to the sea, a weir was built near the head of tidal influence and below the spawning area. This weir

was so constructed that for the adult run in the autumn picket panels could be inserted, and for the fry migration in the spring, galvanized wire screens could be installed. The adults, coming upstream, encountered the wooden fence and passed through leads into pens from which they could be dipped, enumerated, examined and released above the fence. The fry, by reason of the screening set at an angle to the flow of the river, were directed into pens along one bank. From these pens they were dipped, counted, and marked, and then released below the fence.

Data, both qualitative and quantitative, are now available for the spawning runs of 1930, 1932, 1934, 1936, and 1938, and for the fry migrations of 1931, 1933, 1935, 1937, and 1939. A summary of the counts is submitted in Table 1.

**TABLE 1. COUNTS OF THE ADULT AND FRY RUNS OF PINK SALMON AT McCLINTON CREEK FROM 1930 UNTIL 1939**

| Item | Spawning run | | | | |
|---|---|---|---|---|---|
| | 1930 | 1932 | 1934 | 1936 | 1938 |
| Males | 32,955 | 8,003 | 77,477 | 24,221 | 5,549 |
| Females | 33,198 | 7,597 | 77,719 | 28,091 | 5,028 |
| Total | 66,153 | 15,600 | 155,196 | 52,312 | 10,577 |
| Number of eggs | 1,535 ± 12 | 1,758 ± 15 | 1,799 ± 11 | 1,899 ± 12 | 1,698±19 |
| Presumed deposition | 50,950,000 | 13,360,000 | 139,000,000 | 53,345,000 | 8,500,000 |
| Fry migrants | 5,384,000 | 2,230,000 | 12,600,000 | 3,675,000 | 2,020,000 |
| Percentage hatch | 10.6 | 16.7 | 9.1 | 6.9 | 23.8 |

The production in the five seedings has varied from 6.9 to 23.8 per cent of the possible egg deposition, i.e., of the number of eggs calculated to be contained in all the females released above the fence. The mortality of 76.2 to 93.1 per cent may have been caused by many factors. Of these, climatic conditions as they affect water height, velocity of flow, temperature, etc., at all stages from spawning to fry migration, undoubtedly constitute one of the most important factors. Spawning under freshet conditions may result in drying out of the redds when the water falls, or in losses from lack of sufficient water to enable the fry to migrate even though there may be sufficient dampness for incubation and hatching of the eggs. Severe floods may serve to shift the gravel and wash out the developing eggs. Predators also account for a portion of the loss not only through destruction of the adult fish before the sexual products are deposited, but also through the consumption of the fry.

Unfortunately, it has not been possible to maintain an observer on the stream during the incubation periods in order to obtain a precise record of the environmental conditions. In view, however, of the known extremes to which the river is subjected, the variation in production efficiency from cycle to cycle is not unexpected.

It is possible that another factor enters into the situation, namely, the number of spawning fish and the number of eggs in the beds. It may be noted that in 1930, 1934, and 1936 when there were depositions varying from 50,000,000 to 139,000,000 eggs, the percentages varied from 6.9 to 10.6, showing differences of no statistical significance. On the other hand, in 1932 with 13,000,000 eggs, the percentage was 16.7 and in 1938 with 8,500,000 eggs, the smallest spawning, it reached 23.8 per cent. It is suggested, therefore, that the percentage efficiency is highest in the case of small runs. In view of the fact that 50,000,000 and 139,000,000 eggs gave approximately the same percentage hatch, it is possible that there may be a limit below which the percentage will not drop except under conditions of extreme overcrowding. On the other hand there may be a minimum number of spawners below which the efficiency will drop to a very low point rather than rise. Neither of these limits has been encountered but it appears that, until further work is accomplished, the premise must be qualified by stating that *within certain limits and under uniform climatic conditions* the smaller run will provide the greater efficiency of hatch.

In considering production as a whole, there remains the determination of the survival in the sea. This determination rests upon a knowledge of the age at maturity and the migration in relation to commercial catch and spawning place. There is definite information on the former but additional data are being collected on the latter problem.

The long-term experiment reported here has provided both qualitative and quantitative data on the natural production of the pink salmon. To date only the total mortalities have been assessed but an attempt is now being made to discover the extent of the loss in the various periods from the time when the adult salmon migrate upstream to spawn until the entrance of the fry into the sea, namely, spawning, fertilization, incubation, etc. More information is being gathered on the behavior of the fish in the sea. When the major facts concerning propagation are known, it may be possible to regulate escapement, reduce predators, etc., in such a manner that production may be maintained efficiently at a relatively high level.

# CONSIDERATIONS OF THE INTRODUCTION AND DISTRIBUTION OF EXOTIC FISHES IN OREGON[1]

FRANCIS P. GRIFFITHS

*Oregon State Game Commission*
*and*
*Department of Fish and Game Management, Oregon State College*

ABSTRACT

**Many introductions of exotic species have been made without considering the possible effects on native fishes. Of eighty fresh-water and anadromous fishes of Oregon, nineteen have been established by introduction. Eastern brook trout planted in mountain lakes have produced excellent fishing but numerous introductions in low coastal waters have been unproductive. Spiny-rayed fishes have replaced trout in some waters and are becoming numerous in the backwater created by the Bonneville Dam on the Columbia River. The increase in predacious fish may lead to the destruction of young salmon during their migration downstream. The introduction of other exotics such as the channel catfish would appear to be undesirable as long as there is hope of maintaining salmonid fishes. Careful biological study of all factors involved should precede the introduction and distribution of exotic fishes in Oregon.**

---

Past experience in the introduction of alien insects, birds, and mammals, as well as fishes, indicates the need of caution and of thorough study before new species are added to a community of species that exists in natural balance. The decimation or even the extermination of valuable native species may result from the failure to consider all the consequences of liberating apparently harmless exotics. Some introductions of exotic species of fish have been fortunate and have resulted in improved fishing rather than in harm; on the other hand, many have been distinctly harmful.

Numerous enthusiastic sport fishermen in particular believe that the answer to the lack of fish is simply the addition of more fish, preferably of a different variety. Attention and emphasis have often centered on the introduction and propagation of exotic forms rather than on an intelligent program for the conservation and replenishment of native species.

In the western states, many importations have been made simply to satisfy the personal whims of individuals accustomed to fishing for eastern fish. The introductions of other species, such as the carp, have resulted from accidental liberations of fish reared commercially and through the careless distribution of small "pond" fish.

The western coastal states have a relatively small number of native

---

[1]Technical Paper No. 318 of the Agricultural Experiment Station, Oregon State College, Corvallis, Oregon.

fresh-water fish compared with the mid-western or eastern coastal states. Of eighty fresh-water and anadromous fishes known to occur in Oregon (Jewett, 1938), nineteen are non-native species. Less than fifty years ago the most common game fish were steelhead, rainbow, and cutthroat trout. Now we have largemouth black bass, yellow perch, white crappie and calico bass, several sunfishes, warmouth bass and carp, as well as eastern brook, brown, and Mackinaw trout. The following list shows the most important sport fishes in Oregon. Asterisks indicate the species that have been introduced.

SALMONIDAE, the salmon and trout

*Oncorhynchus tschawytscha* (Walbaum), chinook salmon.
*Oncorhynchus kisutch* (Walbaum), silver salmon.
*Oncorhynchus nerka* (Walbaum), sockeye salmon.
*Salmo clarkii clarkii* Richardson, coastal cutthroat trout.
*Salmo gairdnerii gairdnerii* Richardson, steelhead or rainbow trout.
**Salmo trutta* L., brown or Loch Leven trout.
**Cristivomer namaycush* (Walbaum), lake or Mackinaw trout.
**Salvelinus fontinalis* (Mitchill), eastern brook trout.
*Salvelinus malma spectabilis* (Girard), Dolly Varden or bull trout.

GOREGONIDAE, the whitefishes

*Prosopium williamsoni* (Girard), Rocky Mountain whitefish.

AMEIURIDAE, the North American catfishes

**Ameiurus nebulosus* (Le Sueur), small catfish or bullhead.

PERCIDAE, the perches

**Perca flavescens* (Mitchill), yellow perch.

CENTRARCHIDAE, the basses and sunfishes

**Lepomis macrochirus* (Rafinesque), bluegill sunfish.
**Huro salmoides* (Rafinesque), largemouth black bass.
**Pomoxis annularis* (Rafinesque), white crappie.
**Pomoxis nigro-maculatus* (Le Sueur), black crappie or calico bass.

MORONIDAE, the white basses

**Roccus saxatilis* (Walbaum), striped bass.

Besides the fish listed, the following species have been introduced and are sometimes caught: *Alosa sapidissima* (Wilson), shad; *Cyprinus carpio* L., carp; *Ameiurus melas* (Rafinesque), black bullhead; *Chaenobryttus gulosus* (Cuvier and Valenciennes), warmouth bass; *Micropterus dolomieu* (Lacépède), smallmouth black bass; *Lepomis gibbosus* (L.), pumpkinseed sunfish; and *Lepomis cyanellus* (Rafinesque), green sunfish.

Coincident with an increase in variety, there has been a decrease in the numbers of salmonid fishes. Other factors besides competition with introduced species have been largely responsible for the decline of native forms, but there are nevertheless numerous instances where a decrease in trout has followed the introduction of bass, perch, and crappies. The introductions of eastern brook trout into environments similar to its native habitat have resulted in good fishing. The high,

more or less landlocked lakes of the Cascade mountains yield excellent eastern brook trout, but numerous plantings in low coastal waters and in the Willamette Valley have produced no results. Although popularly considered to be adapted to warmer water than the rainbow trout, the brown trout appears to be competing successfully with this fish in the spring- and snow-fed Deschutes River. The headwaters of this stream resemble many of the streams of the lower mountains of southern Germany where the "Bachforelle" is native.

The problem presented by the introduction of exotic species is particularly acute in certain coastal lakes which seem to be about equally suitable for spiny-rayed fish and for salmon and trout. Several large lakes are now providing excellent fishing for the spiny-rayed fish and increasingly poor catches of trout. One lake has so far escaped the introduction of bass and perch but does have a very large population of bullheads (termed locally, catfish), *Ameiurus nebulosus,* along with migratory silver salmon and the resident and sea-run cutthroat trout. The extent to which the introduction of bullheads or "catfish" will affect the salmon and trout population is difficult to determine, but most probably the bullhead will not be beneficial.

The problem of determining whether a body of water should be stocked with spiny-rayed fish or maintained for salmonid fishes is not always easy. It is even more difficult to keep well-meaning but impractical sportsmen from making unlawful introductions without regard to the biology of the lake. Ecological changes have made some bodies of water unsuited for the cold-water species. Bonneville Dam has created a lake area approximately 50 miles in length along whose shores bass and crappie are rapidly becoming very numerous. The possible effect of these fish on the downstream migrants of salmon originating from parents that have run successfully the gauntlet of commercial fishing and man-made obstructions has not been considered. It certainly seems desirable that some study be made to determine the effect the increase in predaceous fish, occasioned by the creation of Lake Bonneville in the Columbia River, will have on young salmon.

The introduction of other fish into Oregon waters is repeatedly suggested by individuals and groups of sportsmen. The two species most frequently mentioned are the smallmouth black bass and the channel catfish, *Ictalurus punctatus* (Rafinesque). Smallmouth black bass are known to be present in one large coastal lake.

Channel catfish have been reported from the fish ladders in Bonneville Dam, but specimens were not obtained and the identification is consequently doubtful. It is hoped that if early introductions of this fish did occur, they were unsuccessful. The data available in the literature on the life histories and habits of smallmouth black bass and channel catfish indicate that both species, should they be widely introduced and be capable of adapting themselves to their new en-

vironment, would be serious food competitors of and predators upon resident salmonid fishes.

It is hoped sincerely that future introductions and distribution of all fish not native to this area will be made as a result of careful biological study and with adequate control, rather than by irresponsible individuals acting without thought of the biological consequences.

## Literature Cited

Jewett, Stanley G., Jr.
1938. A list of the fresh-water and anadromous fishes in Oregon. Leaflet No. 1. Department of Fish and Game Management, Oregon State College, 2 pp.

# FURTHER OBSERVATIONS ON THE FEEDING HABITS OF THE MONTANA GRAYLING (*THYMALLUS MONTANUS*) AND THE BLUEGILL (*LEPOMIS MACROCHIRUS*) IN FORD LAKE, MICHIGAN[1]

JUSTIN W. LEONARD

*Michigan Department of Conservation, Ann Arbor, Michigan*

ABSTRACT

The feeding habits of a small population of Montana grayling in a small landlocked lake in northern Michigan are described in detail on the basis of stomach analyses of specimens taken in April, May, July and October, 1938, and March, 1939. The progress of the experiment based on these grayling was complicated by the unauthorized stocking of bluegills in the lake which, prior to the planting of the grayling, had been freed of all fish by treatment with rotenone.

As was noted in an earlier report on this experiment, immature and adult stages of certain predaceous aquatic insects, notably Odonata and Coleoptera, occupied a most important place in the diet of the grayling. An interesting result of the presence of bluegills in the lake was the fact that by the time the grayling had attained an average standard length of 246.5 millimeters they began to prey upon small bluegill fingerlings. Data are presented to show that all but fingerling bluegills are direct food competitors of the grayling. Observations indicate that the effects of this competition are already resulting in a reduction of the grayling population. It is suggested as probable that the non-reproducing grayling will be unable to maintain satisfactory growth and viability in the face of continued competition from the prolific bluegills.

## INTRODUCTION

In an earlier report the writer (Leonard, 1939) presented an account of an experiment with Montana grayling (*Thymallus montanus* Milner), 5,000 of which were introduced as 4-inch fingerlings into Ford Lake, a small landlocked lake in northern Michigan. This report included a brief discussion of the physical, chemical and biological characteristics of the lake, a series of observations on the feeding habits of the grayling, and a summary of all information available in the literature on the feeding habits of grayling. It was noted that one of the most unusual aspects of the diet of the Ford Lake grayling was the dominant position occupied by various groups of predacious insects, notably Odonata and dytiscid Coleoptera.

The grayling, which were hatched on June 24, 1936, are now (in 1939) completing their third year of life. The first report covered collections made in May and October of 1937. The present report deals with collections made in April, May, July and October, 1938, and March, 1939.

---

[1]Contribution from the Michigan Institute for Fisheries Research.

One aspect of the conditions under which the Ford Lake grayling population exists has undergone a significant alteration since the first observations were recorded. Owing to a misunderstanding, a planting of bluegills (presumably fingerlings) was made in the lake during the summer of 1937. This event was most unfortunate, because all fish had been removed by rotenone treatment prior to the introduction of the grayling, in order that they might be free from the possible competition or predatory activities of any other fishes. The progress of the experiment was not halted, however, and certain discoveries have resulted from the presence of the bluegills. One of the most interesting of these observations is that by the time the grayling had attained an age of 16 months and an average standard length of 246.5 millimeters (average total length, 11.5 inches) they began to prey upon young bluegills. Consumption of fish by Montana grayling has been reported only once (Brown, 1938), and in this instance the prey was small trout fry taken where they were concentrated just below a hatchery outlet. This situation, of course, was not a natural one. The proportion of bluegill fingerlings in the grayling diet rose from 3.5 per cent of the total in October, 1938, to 34.0 per cent in March, 1939. Continued utilization of this food undoubtedly will depend largely upon the degree of success attending the reproduction of the bluegills, since it is obvious that physical limitations would prevent the grayling from feeding upon any but the smaller individuals.

In the ensuing tabulations determinations of food organisms encountered in the grayling stomachs have been made in as great detail as is feasible. The lack of knowledge of the life histories of many of our aquatic insects has prevented specific determinations of many individuals, notably of the midges and caddis flies. Lengths, weights and data on the method of collection of each series of fish are recorded in the text.

All fragments of animal and plant matter too finely comminuted for recognition have been considered as debris. Because the proportions of the various organisms represented in the debris appeared to be in direct ratio to their abundance among the recognizable organisms, the debris has not entered in the calculations of the percentage composition of the stomach contents; however, the relative percentages of animal debris, plant debris and identifiable organisms are listed in the text. Unless specifically indicated otherwise, all aquatic insects were taken in immature stages, terrestrial insects as adults. When specific growth-stages are indicated, "L" stands for larva, "P" for pupa, "N" for nymph and "A" for adult.

Table 1 shows the diet of the grayling for each collection summarized by major taxonomic categories of food organisms. The detailed data for these same collections may be found in Tables 3 to 7. Table 2 provides summarized information for the bluegills corresponding to the data of Table 1, except that the bluegills were all collected on the same date and are recorded by size groups. The detailed information

TABLE 1. RESULTS OF STOMACH ANALYSES OF FIVE COLLECTIONS OF MONTANA GRAYLING SUMMARIZED BY MAJOR FOOD GROUPS, SHOWN AS PERCENTAGES OF TOTAL FOOD VOLUME

| Organism | April 21 1938 | May 8 1938 | July 5-6 1938 | Oct. 29-30 1938 | March 1-2 1939 |
|---|---|---|---|---|---|
| Mollusca | -------- | -------- | trace | -------- | 11.0 |
| Entomostraca | trace | trace | 4.3 | -------- | -------- |
| Malacostraca | 9.7 | trace | 2.4 | trace | -------- |
| Ephemeroptera | 6.5 | 2.0 | 2.2 | 0.1 | 6.5 |
| Odonata | 38.7 | 19.4 | 13.2 | 18.0 | 17.2 |
| Hemiptera | 3.2 | 12.0 | 3.2 | 2.8 | 2.7 |
| Coleoptera | 16.1 | 13.9 | 2.4 | 53.8 | 28.0 |
| Trichoptera | -------- | 0.6 | 12.8 | 0.1 | 0.3 |
| Diptera | 19.3 | 20.4 | 57.9 | trace | 0.3 |
| Hydracarina | -------- | trace | -------- | -------- | -------- |
| Orthoptera* | -------- | -------- | 1.2 | 3.9 | -------- |
| Hemiptera* | -------- | 0.6 | -------- | 0.7 | -------- |
| Homoptera* | -------- | -------- | -------- | 0.3 | -------- |
| Coleoptera* | -------- | 3.9 | 0.2 | 11.7 | -------- |
| Diptera* | -------- | trace | -------- | 1.0 | -------- |
| Hymenoptera* | 6.5 | 27.2 | 0.2 | 4.1 | -------- |
| Araneae* | trace | -------- | -------- | -------- | -------- |
| Fish | -------- | -------- | -------- | 3.5 | 34.0 |

*Terrestrial organisms.

TABLE 2. RESULTS OF STOMACH ANALYSES OF THREE SIZE GROUPS OF BLUEGILLS, SUMMARIZED BY MAJOR FOOD GROUPS, SHOWN AS PERCENTAGES OF TOTAL FOOD VOLUME
Date of Collection October 28-29, 1938

| Organism | Average standard length 21.8 millimeters | Average standard length 40.4 millimeters | Average standard length 117.8 millimeters |
|---|---|---|---|
| Annelida | -------- | -------- | 4.0 |
| Mollusca | -------- | 1.9 | 2.6 |
| Entomostraca | 51.7 | 20.9 | -------- |
| Malacostraca | 6.6 | 4.7 | trace |
| Ephemeroptera | 21.7 | 8.5 | -------- |
| Odonata | -------- | 13.5 | 82.4 |
| Trichoptera | -------- | 1.1 | 0.7 |
| Diptera | 20.0 | 20.7 | 0.5 |
| Hydracarina | -------- | -------- | trace |
| Orthoptera* | -------- | -------- | 6.6 |
| Hemiptera* | -------- | 1.9 | -------- |
| Homoptera* | -------- | 20.0 | -------- |
| Coleoptera* | -------- | 2.2 | 0.2 |
| Diptera* | -------- | 0.3 | -------- |
| Hymenoptera* | -------- | 0.6 | -------- |
| Psocoptera* | -------- | 0.9 | -------- |
| Plant material | -------- | 2.8 | 0.4 |
| Animal debris | -------- | -------- | 2.6 |

*Terrestrial organisms

concerning the food of the three size groups of bluegills are contained in Tables 8 to 10. It appears certain that the three size groups recognized represent only two ages, and that the two smaller groups are composed of specimens of the same age separated by different rates of growth, probably because of varying success in competitive feeding—a condition commonly encountered among centrarchids. Since this paper was prepared a collection of over 100 bluegills of this age group was made (May 24, 1939), by means of artificial flies. The two size classes persisted at this time. Individuals of the larger groups could be recognized as soon as they were hooked by reason of their greater

vigor and endurance, and by their more vivid coloration. The smaller specimens appeared distinctly pale and "washed out."

## Food of the Grayling

*Collection No. 1*—On April 21, 1938, five male and four female grayling were taken on artificial flies. The specimens had the following size ranges: standard length, 183 to 198 millimeters, average 190 millimeters; total length, 204 to 231 millimeters, average 218 millimeters; weight, 58.4 to 83.1 grams, average 72.3 grams (Table 3). The percentages of identifiable organisms and debris were: identifiable organisms, 62 per cent; animal debris, 34 per cent; plant debris, 4 per cent.

During the later afternoon a large number of chironomids began to transform over shallow shoal areas. Their emergence attracted a large part of the grayling population, and for about a half hour, or until a sudden shower began, the water literally boiled with rising fish. A No. 18 Black Gnat fly was used for the collection of specimens, and

**TABLE 3. STOMACH CONTENTS OF FORD LAKE GRAYLING. BASED ON A SERIES OF FIVE MALES AND FOUR FEMALES COLLECTED APRIL 21, 1938. SEE TEXT FOR DETAILS**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Entomostraca | | | | | | | |
| *Diaptomus* sp. | 1 | 12 | 1 | 12 | 12 | 12.0 | trace |
| Malacostraca | | | | | | | |
| *Hyalella knickerbockeri* | 1 | 42 | 4 | 27 | 2 | 10.5 | 9.7 |
| Ephemeroptera | | | | | | | |
| *Ephemera simulans* (N) | 1 | 4 | 2 | 2 | 2 | 2.0 | 3.2 |
| *Blasturus* sp. (N) | 1 | 9 | 3 | 5 | 1 | 3.0 | 3.3 |
| Odonata | | | | | | | |
| *Enallagma* spp. (N) | 2 | 16 | 7 | 5 | 1 | 2.2 | 22.6 |
| *Tetragoneuria* sp. (N) | 1 | 2 | 1 | 1 | 1 | 1.0 | 16.1 |
| Hemiptera | | | | | | | |
| Corixidae (A) | 1 | 6 | 5 | 2 | 1 | 1.2 | 3.2 |
| Coleoptera | | | | | | | |
| Dytiscidae (A) | 2 | 3 | 2 | 2 | 1 | 1.5 | trace |
| Dytiscidae (L) | 1 | 25 | 1 | 25 | 25 | 25.0 | 12.9 |
| Gyrinidae (A) | 1 | 4 | 4 | 1 | 1 | 1.0 | 3.2 |
| Scarabaeidae (A*) | 1 | 2 | 2 | 1 | 1 | 1.0 | trace |
| Elateridae (A*) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Diptera | | | | | | | |
| Tanypodinae (L) | 1 | 2 | 2 | 1 | 1 | 1.0 | trace |
| Chironominae (A) | 2 | 106 | 6 | 31 | 6 | 17.6 | 12.8 |
| Chironominae (P) | 1 | 2 | 2 | 1 | 1 | 1.0 | trace |
| Chironominae (L) | 2 | 4 | 4 | 1 | 1 | 1.0 | 3.2 |
| Ceratopogonidae (L) | 1 | 11 | 5 | 6 | 1 | 2.2 | trace |
| Stratiomyiidae (L) | 1 | 11 | 2 | 8 | 3 | 5.5 | 3.3 |
| Hymenoptera | | | | | | | |
| Tenthredinidae* | 1 | 3 | 3 | 1 | 1 | 1.0 | 6.5 |
| Araneae | | | | | | | |
| Thomisidae* | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |

*Terrestrial organisms.

so avid were the grayling that almost every cast drew a strike. It is not surprising that the Diptera as a group composed 30.6 per cent by volume of the food taken. The large amounts of Odonata nymphs (33.3 per cent) and aquatic Coleoptera (13.9 per cent) probably indicate that the grayling had been occupying and feeding over the shoal areas for some time prior to the peak of the midge emergence.

*Collection No. 2*—Eleven males and seven females were taken by

**TABLE 4. STOMACH CONTENTS OF FORD LAKE GRAYLING. BASED ON A SERIES OF ELEVEN MALES AND SEVEN FEMALES COLLECTED MAY 8, 1938. SEE TEXT FOR DETAILS**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Entomostraca | | | | | | | |
| *Bosmina* | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| *Diaptomus* | 1 | 24 | 5 | 10 | 1 | 5.0 | trace |
| Malacostraca | | | | | | | |
| *Hyalella* | 1 | 21 | 10 | 4 | 1 | 2.1 | trace |
| Ephemeroptera | | | | | | | |
| *Ephemera simulans* (N) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| *Blasturus cupidus* (N) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| *Baetis* sp. (N) | 1 | 15 | 8 | 3 | 1 | 1.9 | 2.0 |
| Odonata | | | | | | | |
| *Enallagma hageni* (N) | 1 | 49 | 15 | 8 | 1 | 3.3 | 19.4 |
| *Tetragoneuria* sp. (N) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Hemiptera | | | | | | | |
| Corixidae (A) | 1 | 18 | 11 | 5 | 1 | 1.6 | 4.0 |
| Notonectidae (A) | 1 | 8 | 7 | 2 | 1 | 1.1 | 8.0 |
| Gerridae (A) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Coleoptera | | | | | | | |
| *Haliplus* sp. (A) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| *Coptotomus* sp. (A) | 1 | 5 | 5 | 1 | 1 | 1.0 | 5.3 |
| *Bidessus* sp. (A) | 1 | 35 | 7 | 17 | 1 | 5.0 | 0.6 |
| Dytiscidae (L) | 1 | 2 | 2 | 1 | 1 | 1.0 | trace |
| Dytiscidae (A) | 1 | 2 | 2 | 1 | 1 | 1.0 | 4.0 |
| Gyrinidae (A) | 2 | 11 | 9 | 2 | 1 | 1.1 | 4.0 |
| Trichoptera | | | | | | | |
| Sericostomatidae (L) | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.6 |
| Diptera | | | | | | | |
| Tanypodinae (P) | 1 | 18 | 13 | 5 | 1 | 1.3 | 0.3 |
| Chironominae (L) | 2 | 56 | 12 | 12 | 1 | 4.7 | 1.3 |
| Chironominae (P) | 1 | 53 | 13 | 12 | 1 | 4.0 | 3.2 |
| Chironominae (A) | 1 | 11 | 4 | 8 | 1 | 2.7 | trace |
| Ceratopogonidae (L) | 1 | 12 | 9 | 4 | 1 | 1.3 | 0.3 |
| *Chaoborus punctipennis* (L) | 1 | 15 | 4 | 9 | 1 | 3.7 | 0.9 |
| Empididae (A) | 1 | 69 | 10 | 20 | 1 | 6.9 | 13.8 |
| Stratiomyiidae (L) | 1 | 3 | 2 | 2 | 1 | 1.5 | 0.6 |
| Hydracarina | 1 | 9 | 6 | 4 | 1 | 1.5 | trace |
| Hemiptera* | | | | | | | |
| Enicocephalidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.6 |
| Coleoptera* | | | | | | | |
| Family? | 3 | 3 | 1 | 1 | 1 | 1.0 | 0.6 |
| Chrysomelidae | 1 | 5 | 3 | 2 | 1 | 1.7 | 3.3 |
| *Aphodius* sp. | 1 | 2 | 2 | 1 | 1 | 1.0 | trace |
| Diptera* | | | | | | | |
| Dolichopodidae | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Hymenoptera* | | | | | | | |
| Formicidae | 1 | 29 | 5 | 8 | 1 | 5.8 | 26.6 |
| Family? | 1 | 9 | 5 | 4 | 1 | 1.8 | 0.6 |

*Terrestrial organisms.

means of artificial flies on May 8, 1938. The size ranges of these specimens were as follows: standard length, 172 to 216 millimeter, average 199.8 millimeters; total length, 220 to 253 millimeters, average 233.6 millimeters; weight, 57.6 to 112.0 grams, average 91.5 grams (Table 4). The percentages of identifiable organisms and debris were: identifiable organisms, 64.6 per cent; animal debris, 30.2 per cent; plant debris, 5.2 per cent.

When this collection was made, great numbers of empidids, or dance-flies, were swarming over the water. Their ready availability, coupled with the gregarious habits of feeding grayling, doubtless explains the fact that the empidids alone accounted for over two-thirds of the total volume of Diptera consumed. Nymphs of *Enallagma hageni,* although bulking slightly smaller than the empidids, were taken more generally, and were encountered in all but three stomachs. Corixidae were even more prevalent and, although making up only 4 per cent of the total volume, occurred in all eighteen stomachs. Of the terrestrial insects, only the Hymenoptera made a significant contribution to the diet. The group was represented almost entirely by large winged females of the common carpenter ant, *Camponotus herculeanus pennsylvanicus.* Adults of the minute dytiscid beetle, *Bidessus* sp., found commonly in the grayling stomachs previously reported on, occurred only in the May 8 collection.

*Collection No. 3*—A series of seventeen males and eleven females was collected by means of a graded gill net set at 9:30 p.m., July 5, and lifted at 10:00 a.m., July 6, 1938. The size range of these individuals was as follows: standard length, 214 to 250 millimeters, average 226.5 millimeters; total length, 254 to 295 milimeters, average 268.9 millimeters; weights not available (Table 5). The percentages of identifiable food organisms and debris were: identifiable organisms, 52.7 per cent; animal debris, 40.3 per cent; plant debris, 7.0 per cent.

Stomachs from this collection contained a higher percentage of plankton (4.3 per cent, composed almost entirely of *Bosmina*) than any others reported here. The Odonata, although still well represented, were at their lowest point, probably because the peak of the emergence season had just passed. The extraordinarily large amount of Diptera, made up almost wholly of larvae and pupae of a chironomine midge tentatively determined as *Limnochironomus modestus,* is almost certainly due to increased activity on the part of these organisms in anticipation of emergence. As a result the midges were detected and captured more readily by the grayling than is usual. The same conclusion is even more certainly justified as an explanation of the abundance of the Trichoptera which, represented almost entirely by pupae of *Oecetis inconspicua,* made the first significant contribution to the diet by this group since the inception of the study.

It is possible that an explanation of the small amounts of water beetles and all terrestrial insects present in these stomachs lies in the fact that the collection was made at night, when few terrestrial in-

**TABLE 5. STOMACH CONTENTS OF FORD LAKE GRAYLING. BASED ON A SERIES OF SEVENTEEN MALES AND ELEVEN FEMALES COLLECTED JULY 5 AND 6, 1938. SEE TEXT FOR DETAILS.**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Mollusca | | | | | | | |
| *Physa* sp. | 1 | 2 | 2 | 1 | 1 | 1.0 | trace |
| *Pisidium* sp. | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Entomostraca | | | | | | | |
| *Bosmina* sp. | 1 | ±7,500 | 3 | ±6,000 | 1 | ±3,000.0 | 4.3 |
| *Diaptomus* sp. | 1 | 6 | 2 | 5 | 1 | 3.0 | trace |
| Malacostraca | | | | | | | |
| *Hyalella* sp. | 1 | 67 | 15 | 14 | 1 | 4.4 | 2.4 |
| Ephemeroptera | | | | | | | |
| Baetidae | 1 | 8 | 6 | 3 | 1 | 1.3 | 0.2 |
| *Ephemerella bicolor* (N) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| *Caenis simulans* (N) | 1 | 131 | 9 | 46 | 1 | 14.5 | 2.0 |
| *Tricorythodes allectus* (N) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Odonata | | | | | | | |
| *Enallagma hageni* | 1 | 7 | 5 | 2 | 1 | 1.4 | 0.3 |
| *Anax junius* | 1 | 78 | 18 | 14 | 1 | 4.3 | 10.8 |
| Libellulidae | 2 | 8 | 5 | 3 | 1 | 1.6 | 0.4 |
| *Tetragoneuria* sp. | 1 | 3 | 1 | 3 | 3 | 3.0 | 1.7 |
| Hemiptera | | | | | | | |
| Corixidae (A) | 1 | 38 | 12 | 9 | 1 | 3.1 | 3.0 |
| Notonectidae (A) | 1 | 5 | 4 | 2 | 1 | 1.2 | 0.2 |
| Coleoptera | | | | | | | |
| *Haliplus* sp. (L) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| *Haliplus* sp. (A) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Gyrinidae (A) | 1 | 14 | 7 | 3 | 1 | 2.0 | 1.9 |
| Dytiscidae (L) | 2 | 3 | 2 | 2 | 1 | 1.5 | 0.3 |
| Dytiscidae (A) | 1 | 2 | 2 | 1 | 1 | 1.0 | 0.2 |
| Trichoptera | | | | | | | |
| Polycentropidae (L) | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.2 |
| *Oecetis inconspicua* (P) | 1 | 371 | 6 | 86 | 1 | 61.8 | 12.4 |
| Sericostomatidae (P) | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.2 |
| Family? (A) | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Diptera | | | | | | | |
| Chironominae (L) | 2 | 4,836 | 27 | 710 | 3 | 179.0 | 29.7 |
| Chironominae (P) | 2 | 2,084 | 27 | 250 | 2 | 77.1 | 27.6 |
| Ceratopogonidae (L) | 1 | 12 | 2 | 8 | 4 | 6.0 | trace |
| Ceratopogonidae (P) | 1 | 34 | 16 | 7 | 1 | 2.1 | 0.2 |
| *Chaoborus punctipennis* (L) | 1 | 10 | 5 | 4 | 1 | 2.0 | trace |
| Stratiomyiidae (L) | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.2 |
| *Chrysops* sp. (L) | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.2 |
| Orthoptera* | | | | | | | |
| *Ceuthophilus maculatus* | 1 | 1 | 1 | 1 | 1 | 1.0 | 1.2 |
| Coleoptera* | | | | | | | |
| Scarabaeidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.2 |
| Family? | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Hymenoptera* | | | | | | | |
| *Camponotus pennsylvanicus* | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.2 |

*Terrestrial organisms.

sects were available, and by means of a gill net, which was set too deep to take individuals feeding at or very near the surface. A collection made just at dusk or nearer the surface might have revealed a larger proportion of terrestrial and surface-inhabiting aquatic insects.

Another, perhaps more probable explanation, is that the surface

layer of the water, which warmed to 76° F. during the afternoon preceding the net-set, may have had a sufficiently high temperature to exclude the grayling from it.

*Collection No. 4*—On October 29 and 30, 1938, nine males and seven

**TABLE 6. STOMACH CONTENTS OF FORD LAKE GRAYLING. BASED ON A SERIES OF NINE MALES AND SEVEN FEMALES COLLECTED OCTOBER 29-30, 1938. SEE TEXT FOR DETAILS.**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Amphipoda | | | | | | | |
| *Hyalella* sp. | 1 | 4 | 3 | 2 | 1 | 1.3 | trace |
| Ephemeroptera | | | | | | | |
| *Ephemera simulans* | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.1 |
| *Blasturus cupidus* | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Odonata | | | | | | | |
| *Gomphus exilis* (N) | 1 | 4 | 3 | 2 | 1 | 1.3 | 3.8 |
| *Anax junius* (N) | 1 | 18 | 7 | 4 | 1 | 2.6 | 12.2 |
| *Anax junius* (A) | 1 | 2 | 1 | 2 | 2 | 2.0 | 0.1 |
| Libellulidae (N) | 1 | 7 | 5 | 3 | 1 | 1.4 | 1.2 |
| Libellulidae (A) | 1 | 2 | 2 | 1 | 1 | 1.0 | 0.7 |
| Hemiptera | | | | | | | |
| Corixidae (A) | 2 | 26 | 12 | 5 | 1 | 2.1 | 2.1 |
| *Notonecta undulata* (A) | 1 | 2 | 1 | 2 | 2 | 2.0 | 0.7 |
| Coleoptera | | | | | | | |
| Dytiscidae (A) | 2 | 32 | 14 | 4 | 1 | 2.3 | 24.0 |
| Gyrinidae (A) | 2 | 68 | 13 | 19 | 1 | 5.2 | 29.1 |
| Hydrophilidae (A) | 1 | 4 | 3 | 2 | 1 | 1.3 | 0.7 |
| Trichoptera | | | | | | | |
| Sericostomatidae (L) | 1 | 2 | 2 | 1 | 1 | 1.0 | 0.1 |
| Diptera | | | | | | | |
| Chironomidae | 1 | [1]4 | 4 | 1 | 1 | 1.0 | trace |
| Orthoptera* | | | | | | | |
| *Ceuthophilus maculatus* | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.1 |
| Locustidae | 1 | 2 | 1 | 2 | 2 | 2.0 | 3.8 |
| Hemiptera* | | | | | | | |
| Miridae | 2 | 21 | 9 | 5 | 1 | 2.3 | 0.6 |
| Lygaeidae | 2 | 4 | 2 | 3 | 1 | 2.0 | trace |
| Pentatomidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.1 |
| Homoptera* | | | | | | | |
| Cercopidae | 2 | 3 | 2 | 2 | 1 | 1.3 | 0.2 |
| Aphididae | 1 | 21 | 6 | 9 | 2 | 3.5 | 0.1 |
| Coleoptera* | | | | | | | |
| Staphylinidae | 1 | 2 | 2 | 1 | 1 | 1.0 | trace |
| Buprestidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.1 |
| Tenebrionidae | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Scarabaeidae (*Aphodius* sp.) | 2 | 176 | 15 | 29 | 1 | 11.7 | 11.2 |
| Chrysomelidae | 2 | 4 | 4 | 1 | 1 | 1.0 | 0.1 |
| Curculionidae | 1 | 4 | 2 | 2 | 2 | 2.0 | 0.3 |
| Diptera* | | | | | | | |
| Bibionidae | 1 | 2 | 2 | 1 | 1 | 1.0 | 0.3 |
| Tachinidae | 2 | 2 | 1 | 2 | 2 | 2.0 | 0.7 |
| Hymenoptera* | | | | | | | |
| Ichneumonidae | 2 | 3 | 3 | 1 | 1 | 1.0 | 0.8 |
| Braconidae | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Formicidae | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Vespidae (*V. maculata*) | 1 | 7 | 7 | 1 | 1 | 1.0 | 3.3 |
| Fish | | | | | | | |
| Bluegill (*L. macrochirus*) | 1 | 9 | 5 | 3 | 1 | 1.8 | 3.5 |

*Terrestrial organisms.
[1]1 larva, 3 pupae.

females were taken on artificial flies. The size ranges of these specimens were as follows: standard length, 230 to 258 millimeters, average 246.5 millimeters; total length, 275 to 311 millimeters, average 292.8 millimeters; weight, 154.4 to 224.8 grams, average 185.3 grams (Table

**TABLE 7. STOMACH CONTENTS OF FORD LAKE GRAYLING. BASED ON A SERIES OF FOUR MALES AND SIX FEMALES COLLECTED MARCH 1-2, 1939. SEE TEXT FOR DETAILS**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Mollusca | | | | | | | |
| *Physa* sp. | 1 | 11 | 2 | 6 | 5 | 5.5 | 11.0 |
| *Helisoma* sp. | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Ephemeroptera | | | | | | | |
| *Ephemera simulans* (N) | 1 | 6 | 2 | 4 | 2 | 3.0 | 1.3 |
| *Hexagenia occulta* (N) | 1 | 2 | 2 | 1 | 1 | 1.0 | 3.0 |
| *Stenonema tripunctatum* (N) | 1 | 2 | 2 | 1 | 1 | 1.0 | 1.3 |
| *Blasturus cupidus* (N) | 1 | 23 | 4 | 20 | 1 | 5.7 | 0.9 |
| Odonata | | | | | | | |
| *Enallagma* spp. | 2 | 58 | 2 | 57 | 1 | 8.8 | 1.8 |
| *Aeshna* sp. | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.9 |
| *Anax junius* | 1 | 8 | 4 | 4 | 1 | 2.0 | 11.6 |
| Libellulidae | 2 | 4 | 3 | 2 | 1 | 1.3 | 2.9 |
| Hemiptera | | | | | | | |
| Corixidae (A) | 1 | 9 | 5 | 2 | 1 | 1.8 | 2.7 |
| Coleoptera | | | | | | | |
| Dytiscidae (A) | 1 | 14 | 8 | 5 | 1 | 2.8 | 9.3 |
| Gyrinidae (A) | 1 | 49 | 8 | 17 | 2 | 6.1 | 18.7 |
| Trichoptera | | | | | | | |
| Sericostomatidae (P) | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.3 |
| Diptera | | | | | | | |
| Chironominae (L) | 1 | 49 | 8 | 14 | 1 | 6.1 | 0.3 |
| Fish | | | | | | | |
| Bluegill (*L. macrochirus*) | 1 | 40 | 10 | 8 | 1 | 5.0 | 34.0 |

**TABLE 8. STOMACH CONTENTS OF BLUEGILLS FROM FORD LAKE, MICHIGAN. BASED ON A SERIES OF NINE SPECIMENS COLLECTED OCTOBER 28-29, 1938. (Size Ranges: Standard length 15-26 millimeters, average 21.8 millimeters; total length 18-23 millimeters, averaging 27.4 millimeters)**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Entomostraca | | | | | | | |
| *Bosmina* sp. | 1 | 147 | 8 | 50 | 3 | 18.4 | 51.7 |
| Malacostraca | | | | | | | |
| *Hyalella knickerbockeri* | 1 | 2 | 1 | 2 | 2 | 2.0 | 6.6 |
| Ephemeroptera | | | | | | | |
| *Paraleptophlebia* sp. | 1 | 3 | 3 | 1 | 1 | 1.0 | 21.7 |
| Diptera | | | | | | | |
| *Chironomus* spp. | 2 | 15 | 4 | 8 | 1 | 1.9 | 20.0 |

6). The percentages of identifiable food organisms and debris were: identifiable organisms 63.4 per cent; animal debris, 28.3 per cent; plant debris, 8.3 per cent.

In this collection the diet was dominated by adult aquatic Coleoptera, especially Dytiscidae (*Acilius* and *Coptotomus*) and Gyrinidae, each family represented by two species. The Odonata were next in importance; almost all of their volume was due to nymphs of *Anax junius*. The cooling of the surface waters is reflected in the marked increase in the diet of a wide variety of terrestrial insects, demonstrating a willingness on the part of the grayling to feed at the surface when temperature conditions are favorable.

For the first time fish appeared in the diet. It may be concluded

**TABLE 9. STOMACH CONTENTS OF BLUEGILL FINGERLINGS FROM FORD LAKE, MICHIGAN. BASED ON A SERIES OF FIFTEEN SPECIMENS COLLECTED OCTOBER 28-29, 1938. (Size Range: Standard length 33-50 millimeters, average 40.4 millimeters; total length 42-63 millimeters, average 50.9 millimeters)**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Mollusca | | | | | | | |
| *Helisoma* sp. | 1 | 2 | 1 | 2 | 2 | 2.0 | 1.9 |
| Entomostraca | | | | | | | |
| *Bosmina* sp. | 1 | 38 | 3 | 20 | 3 | 16.0 | 8.7 |
| *Diaptomus* sp. | 1 | 51 | 6 | 20 | 4 | 8.5 | 12.2 |
| Malacostraca | | | | | | | |
| *Hyalella knickerbockeri* | 1 | 14 | 5 | 6 | 1 | 2.8 | 4.7 |
| Ephemeroptera | | | | | | | |
| *Ephemera simulans* | 1 | 1 | 1 | 1 | 1 | 1.0 | 2.2 |
| *Paraleptophlebia* sp. | 1 | 5 | 3 | 3 | 1 | 1.6 | 3.8 |
| *Baetis* sp. | 1 | 1 | 1 | 1 | 1 | 1.0 | 2.5 |
| Odonata | | | | | | | |
| *Enallagma* sp. | 1 | 4 | 1 | 1 | 1 | 1.0 | 13.5 |
| Trichoptera | | | | | | | |
| Sericostomatidae | 1 | 3 | 1 | 1 | 1 | 1.0 | 1.1 |
| Diptera | | | | | | | |
| Chironominae | 2 | 111 | 11 | 30 | 1 | 10.9 | 20.7 |
| Psocoptera* | | | | | | | |
| Psocidae | 1 | 2 | 1 | 1 | 1 | 1.0 | 0.9 |
| Hemiptera* | | | | | | | |
| Miridae | 1 | 1 | 1 | 1 | 1 | 1.0 | 1.9 |
| Homoptera* | | | | | | | |
| Cicadellidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.3 |
| Aphididae | 1 | 33 | 7 | 9 | 3 | 4.7 | 19.7 |
| Coleoptera* | | | | | | | |
| Staphylinidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.3 |
| Scarabaeidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 1.6 |
| Family? | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.3 |
| Diptera* | | | | | | | |
| Family? | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.3 |
| Hymenoptera* | | | | | | | |
| Ichneumonidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.6 |
| Cynipidae | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Algae | 2 | .... | 4 | .... | .... | .... | 2.8 |

*Terrestrial organisms.

that the grayling were at this time just attaining a size sufficient to enable them to prey upon the small bluegills. Svetvidov (1931) stated that the white grayling from Lake Baikal feeds on fish and amphipods; Heckel and Kner (1858) and von Siebold (1863) listed minnows and fry as regular items in the food of the European grayling. Huitfeldt-Kaas (1917) reported finding three small *Cottus poecilopus* in stomachs of European grayling. As has been pointed out above, there are no known records of the Michigan grayling feeding upon fish, and the only record of Montana grayling feeding on fish is based on a rather unnatural situation where trout fry were abnormally abundant, just below the drainage outlet of a fish hatchery.

*Collection No. 5*—On March 1 and 2, 1939, four males and six females were secured by angling through the ice. Burrowing mayfly nymphs were used as bait. The size ranges of the specimens were: standard length, 230 to 269 millimeters, average 252.2 millimeters; total length, 272 to 314 millimeters, average 298.3 millimeters; weight, 179 to 240.5 grams, average 212.0 grams (Table 7). The percentages of

**TABLE 10. STOMACH CONTENTS OF BLUEGILLS FROM FORD LAKE, MICHIGAN. BASED ON A SERIES OF EIGHTEEN SPECIMENS COLLECTED OCTOBER 28-29, 1938. (Size Range: Standard length 105-130 millimeters, average 117.8 millimeters; total length 132-160 millimeters, average 146.8 millimeters)**

| Organism | Number of species | Number of individuals | Number of stomachs containing organisms | Most organisms in any stomach | Least organisms in any stomach | Average number of organisms in stomachs containing them | Percentage of total volume, less debris |
|---|---|---|---|---|---|---|---|
| Annelida | | | | | | | |
| Lumbricidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 4.0 |
| Mollusca | | | | | | | |
| *Helisoma* sp. | 1 | 4 | 4 | 1 | 1 | 1.0 | 2.2 |
| *Musculium* sp. | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.4 |
| Malacostraca | | | | | | | |
| *Hyalella knickerbockeri* | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Odonata | | | | | | | |
| *Gomphus exilis* | 1 | 4 | 3 | 2 | 1 | 1.3 | 13.1 |
| *Anax junius* | 1 | 3 | 3 | 1 | 1 | 1.0 | 10.6 |
| *Tetragoneuria cynosura simulans* | 1 | 6 | 2 | 3 | 3 | 3.0 | 18.6 |
| *Ladona julia* | 1 | 16 | 7 | 6 | 1 | 2.3 | 35.4 |
| *Celithemis elisa* | 1 | 2 | 2 | 1 | 1 | 1.0 | 4.7 |
| Trichoptera | | | | | | | |
| Phryganeidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.7 |
| Diptera | | | | | | | |
| Chironomidae | 2 | 14 | 4 | 7 | 1 | 3.5 | 0.5 |
| Ceratopogonidae | 1 | 7 | 2 | 4 | 3 | 3.5 | trace |
| Hydracarina | | | | | | | |
| Hydrachnidae | 1 | 1 | 1 | 1 | 1 | 1.0 | trace |
| Orthoptera* | | | | | | | |
| *Ceuthophilus meridionalis* | 1 | 1 | 1 | 1 | 1 | 1.0 | 6.6 |
| Coleoptera* | | | | | | | |
| Carabidae | 1 | 1 | 1 | 1 | 1 | 1.0 | 0.2 |
| Animal debris | ---- | ---- | 1 | ---- | ---- | ---- | 2.6 |
| Plant debris | ---- | ---- | 2 | ---- | ---- | ---- | 0.4 |

*Terrestrial organisms.

identifiable food organisms and debris were: identifiable organisms, 71.8 per cent; animal debris, 17.0 per cent; plant debris, 11.2 per cent.

Aside from the large amount of bluegill fry consumed, the most interesting feature of this collection was the occurrence, for the first time, of significant amounts of snails. Dragonfly nymphs and adult water beetles were abundant, as usual. Aquatic Diptera, represented by chironomine larvae, were present in negligible quantity.

## Food of the Bluegill as Related to the Welfare of the Grayling

An examination of the figures listed in Tables 2, 8, 9, and 10, shows at a glance that bluegills and grayling in Ford Lake feed largely upon the same groups of invetebrates. There are apparent considerable differences among the diets of the three size groups of bluegills. Members of the group of smallest fish fed almost exclusively on plankton, small mayfly nymphs and chironomids. Plankton, chironomids and aphids bulked about the same in the group of middle-sized fish, but the Odonata were almost as abundant, and many other organisms were present in smaller amounts. The largest specimens fed on anisopteran dragonfly nymphs almost to the exclusion of other groups. It would appear that members of the group of middle-sized individuals fed at the surface more readily than did the smallest or largest individuals.

Some workers believe that competition from more aggressive, introduced species of fish is the principal cause for the extinction of the Michigan grayling and for the current decrease in the numbers of Montana grayling in some of their native waters many of which, in recent years, have been stocked with brown, rainbow, and eastern brook trout.

There exists a strong likelihood that the grayling will fail rapidly in Ford Lake, due to the competitive food habits of the prolific bluegill. Already there have been noted indications of a marked drop in the grayling population and although definite figures will not be available until the population has been removed it is hardly open to question that the great increase in the number of bluegills has already had a serious effect upon the grayling. The completion of the Ford Lake experiment should provide an answer to the question of whether or not a non-reproducing population of Montana grayling can live and grow successfully in a lake which contains such a fecund and highly competitive species as the bluegill.

## Literature Cited

Brown, C. J. D.
1938. The feeding habits of the Montana grayling (*Thymallus montanus*). Jour. Wildlife Management, Vol. 2, No. 3, pp. 135-145.

Heckel, J., and R. Kner
1858. Die Süsswasserfische der östreichischen Monarchie, mit Rücksicht auf die angränzenden Länder. S. x, + 388. Wilhelm Engelmann, Leipzig.

Huitfeldt-Kaas, H.
1917. Mjøsens Fisker og Fiskerier. Kgl. Norske Videnskabers Selskabs Skrifter, 1916, Nr. 2, S. iv, + 257, Trondhjem.

Leonard, J. W.
1939. The feeding habits of the Montana grayling (*Thymallus montanus* Milner) in Ford Lake, Michigan. Trans. Am. Fish Soc., 1938, Vol. 68, pp. 188-195.

Svetvidov, A.
1931. Beiträge zur Systematik und zur Biologie der Æschen des Baikalsees. Trav. Stat. Limn. Lac. Bajkal, Leningrad, Vol. 1, pp. 1-199.

von Siebold, C. Th. E.
1863. Die Süsswasserfische von Mitteleuropa. S. viii + 430. Wilhelm Engelmann, Leipzig.

# EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON PLANKTON PRODUCTION AND BLUEGILL BREAM CARRYING CAPACITY OF PONDS[1]

E. V. Smith and H. S. Swingle

*Alabama Agricultural Experiment Station, Auburn, Alabama*

## Abstract

Small, excavated ponds were stocked with one-year-old bluegill bream (*Lepomis macrochirus*) in May, 1936, and drained in November. The number and total weight of fish in each pond were determined. Different ponds were fertilized with an inorganic fertilizer, laying mash, cottonseed meal, and cottonseed meal and superphosphate. Water samples were taken from each pond at intervals of two weeks throughout the season for quantitative and qualitative plankton determinations.

An unfertilized control pond had the lowest average plankton production and the lowest carrying capacity for bluegill bream. The pond fertilized with cottonseed meal alone had the next lowest average plankton production and the next lowest carrying capacity. The pond fertilized with laying mash produced an average plankton yield about one and one-half times as great as that fertilized with cottonseed meal, and the increase in carrying capacity for bluegills was of the same magnitude. Adding superphosphate to the cottonseed meal doubled the average plankton production and almost doubled the carrying capacity for bluegill bream. An inorganic fertilizer proved best, producing the greatest amount of plankton and fish.

When inorganic fertilizers were used the entire food supply of the pond was dependent upon the production of phytoplankton but when organic fertilizers were used, they were partly utilized directly by animal organisms and the phytoplankton phase was more or less omitted. Consequently, organic fertilizers may produce the same fish yields as inorganic fertilizers but at lower levels of plankton abundance.

## Introduction

Under natural conditions most fish are dependent, either directly or indirectly, on plankton for food. Some species, such as goldfish (*Carassius auratus*), golden shiners (*Notemigonus crysoleucas*) and gizzard shad (*Dorosoma cepedianum*) use phytoplankton, along with various groups of organisms, for food. Others, like bluegill bream (*Lepomis macrochirus*), small crappie (*Pomoxis nigro-maculatus* and *P. annularis*), and small black bass (*Huro salmoides* and species of *Micropterus*) feed on zooplankton and the larvae of various insects. These food organisms in turn, eat phytoplankton directly, or the bacteria that decompose phytoplankton and other organic matter. Large crappie and black bass feed on the smaller fish and are, therefore, indirectly dependent on plankton.

Since plankton is so important, any factor that would increase the production of plankton, should increase fish production also. Pond-fish-culturists have used many fertilizers in an effort to increase the

[1]Published with the approval of the Director.

productivity of ponds. Various organic fertilizers, alone or with superphosphate, have been used widely in hatcheries in this country. Davis and Wiebe (1930) used a mixture of sheep manure and superphosphate in bass-rearing ponds with good results. They also obtained satisfactory results with soybean meal. Meehean (1933) tried sheep manure, cow manure, cottonseed meal, and soybean meal as fertilizers for bass-rearing ponds. Soybean meal was more efficacious in producing organisms than sheep manure, and cottonseed meal was better than soybean meal in this respect. Hogan (1933) fertilized bass-rearing ponds with various organic and inorganic fertilizers. The best results were obtained from a mixture of cottonseed meal and superphosphate. Davis and Wiebe (1930) discussed the use of inorganic fertilizers (phosphorus, potassium, and nitrogen) by several European workers. Swingle and Smith (1939a) found that the use of a complete inorganic fertilizer greatly increased the production of plankton and fish.

Meehean (1935) stated, "Samples taken in ponds, especially with reference to Oklahoma and Louisiana, have revealed that phytoplankton is of minor importance as to volume and numbers." As a result of his studies on ponds fertilized with cottonseed meal, he concluded (*loc. cit.*), "In fertilized ponds the organic matter from zooplankton and phytoplankton sources is insignificant as compared with that from bacteria." Smith and Swingle (1939), on the other hand, found that phytoplankton constituted the bulk of the organic matter in ponds fertilized with inorganic fertilizers. A positive and almost proportionate relationship between average plankton production and carrying capacity for bluegill bream was found. The present paper gives the results of fertilizing ponds with organic and inorganic fertilizers, and helps to explain the differences between the findings of Meehean and of Smith and Swingle.

## Experimental Methods and Results

The experiments were conducted in a series of small excavated ponds. Each pond had an area of approximately 334 square feet and a uniform depth of 3 feet. The water supply for the ponds flowed by gravity through a pipe line that led from an unfertilized storage pond. Each pond was stocked, on May 22, 1936, with 100 fingerling bluegill bream (*Lepomis macrochirus*). The total weight of fish placed in each pond was 1.25 pounds, equivalent to approximately 180 pounds per acre.

Pond 15 was fertilized with an inorganic fertilizer consisting of superphosphate, ammonium sulfate, and basic slag. Four equal applications of fertilizer were made on May 22, June 19, July 29, and September 3, the total being 42 pounds of superphosphate, 8 pounds of ammonium sulfate, and 40 pounds of basic slag. Pond 4 received 1 pound of cottonseed meal at weekly intervals during the experiment, and Pond 6 received laying mash at the same rate and interval. One pound of

cottonseed meal was added to Pond 18 each week, and 42 pounds of superphosphate was added in four equal applications. Pond 5 was an unfertilized control. Methods of distributing inorganic fertilizers over small ponds, and the most effective ratios of inorganic constituents of the fertilizers were discussed by Swingle and Smith (1939a, 1939b).

A representative water sample was taken from each pond every two weeks, and quantitative and qualitative plankton determinations were made. Methods used in taking the samples and in making the determinations were those described by Smith and Swingle (1939). The amount of plankton (as p.p.m. organic matter) present in each pond on each sampling date is recorded in Table 1. The average plankton production for each pond from the beginning of the experiment up to and including the sample for each date is recorded in the same table; the average at the last sampling date is considered to be the average for the season.

**TABLE 1. PLANKTON PRODUCTION IN PONDS FERTILIZED WITH VARIOUS ORGANIC AND INORGANIC FERTILIZERS**[1]

| Sampling date | Plankton present (as p.p.m. organic matter) | | | | | Average plankton production to date (as p.p.m. organic matter) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1936 | Pond 5 | Pond 4 | Pond 6 | Pond 18 | Pond 15 | Pond 5 | Pond 4 | Pond 6 | Pond 18 | Pond 15 |
| May 29 | 2.9 | 2.3 | 2.9 | 4.3 | 14.0 | 2.9 | 2.3 | 2.9 | 4.3 | 14.0 |
| June 12 | 4.8 | 4.7 | 4.7 | 12.8 | 26.9 | 3.9 | 3.5 | 3.8 | 8.6 | 20.5 |
| June 26 | 4.5 | 4.0 | 6.3 | 17.8 | 66.4 | 4.1 | 3.7 | 4.6 | 11.6 | 35.8 |
| July 10 | 6.3 | 9.1 | 18.8 | 13.0 | 23.6 | 4.6 | 5.0 | 8.2 | 12.0 | 32.7 |
| July 24 | 5.4 | 12.3 | 4.8 | 10.6 | 14.9 | 4.8 | 6.5 | 7.5 | 11.7 | 29.2 |
| August 7 | 4.3 | 9.2 | 19.4 | 26.3 | 42.8 | 4.7 | 6.9 | 9.5 | 14.1 | 31.4 |
| August 21 | 4.0 | 6.4 | 14.6 | 13.6 | 44.7 | 4.6 | 6.9 | 10.2 | 14.1 | 33.3 |
| September 11 | 8.3 | 14.5 | 10.9 | 13.5 | 42.7 | 5.1 | 7.8 | 10.3 | 14.0 | 34.5 |
| September 25 | 6.3 | 10.2 | 8.4 | 12.2 | 26.8 | 5.2 | 9.1 | 10.1 | 13.8 | 33.6 |
| October 9 | 6.6 | 5.8 | 10.6 | 17.7 | 15.4 | 5.3 | 7.8 | 10.1 | 14.2 | 31.8 |
| October 23 | 2.9 | 7.5 | 15.3 | 27.9 | 22.8 | 5.1 | 7.8 | 10.6 | 15.4 | 31.0 |

[1]Organic fertilizers added each week and inorganic fertilizers added in four equal quantities on May 22, June 19, July 29, and September 3, 1936. Pond 5 was an unfertilized control, Pond 4 received cottonseed meal, Pond 6 received laying mash, Pond 18 received cottonseed meal and superphosphate, and Pond 15 received superphosphate, ammonium sulfate, and basic slag.

The ponds were drained November 17 and 18, 1936. The bluegills from each pond were counted and weighed. The fish, which were a year old at stocking, spawned in every pond. There was some mortality in all the ponds; 61 per cent of the original stock died in Pond 5, 26 per cent in Pond 4, 23 per cent in Pond 6, 12 per cent in Pond 15, and 10 per cent in Pond 18. The number and weight of fish are recorded in Table 2.

## The Relative Effectiveness of Inorganic and Organic Fertilizers

Pond 15, which received inorganic fertilizer, had the highest plankton production and also the highest carrying capacity for bluegill

TABLE 2. AMOUNT OF STOCKING AND CARRYING CAPACITY FOR BLUEGILL BREAM IN PONDS FERTILIZED WITH VARIOUS ORGANIC AND INORGANIC FERTILIZER

| Pond No. | Fertilizer used | Placed in ponds May 22, 1936 | | Recovered from ponds November 17 and 18, 1936 | | |
|---|---|---|---|---|---|---|
| | | Number per pond | Pounds per acre | Number 2-year olds[1] | Number 1-year olds[2] | Total weight per acre (pounds) |
| 5 | None | 100 | 180 | 29 | 35 | 92.7 |
| 4 | Cottonseed meal | 100 | 180 | 74 | 286 | 295.4 |
| 6 | Laying mash | 100 | 180 | 77 | 405 | 451.8 |
| 18 | Cottonseed meal and superphosphate | 100 | 180 | 90 | 878 | 578.8 |
| 15 | Superphosphate, ammonium sulfate, basic slag | 100 | 180 | 88 | 184 | 588.0 |

[1]One year old when placed in ponds.
[2]Hatched in ponds.

bream. This is not in accord with Meehean's statement (1935): "Fertility cannot be maintained through the use of commercial fertilizers alone since carbohydrate material is indispensable to bacterial activity in the pond." In making this statement, Meehean failed to take into consideration the fact that commercial fertilizers may induce a heavy growth of green algae. These plants possess chlorophyll, carry on photosynthesis, and manufacture carbohydrates. As a matter of fact, these organisms supply organic nitrogen as well as organic carbon to bacteria and other organisms.

No pond in which an organic fertilizer was used gave as high a yield as did the pond fertilized with the inorganic fertilizer. Pond 4, fertilized with cottonseed meal alone, had an average plankton production of 7.8 p.p.m. organic matter, and supported 295.4 pounds of bluegill bream per acre. Pond 15, which received the inorganic fertilizer, had an average plankton production of 31.0 p.p.m. organic matter, and a carrying capacity of 588 pounds of bluegills per acre. The two ponds had approximately a 1:4 ratio with respect to plankton, but only a 1:2 ratio with respect to fish. When the productivities of the other ponds were compared with those of Pond 15, the following ratios were found: for Pond 6, to which laying mash was applied, 1:3 for plankton and 1:1.5 for bluegills; for Pond 18 that received cottonseed meal and superphosphate, 1:2 for plankton and 1:1.0 for fish.

In other words, the concept of a positive and proportionate relationship between plankton production and carrying capacity does not apply when ponds that have been fertilized with organic fertilizers are compared with those in which inorganic fertilizers have been used. This apparent discrepancy is not unexpected and is explained readily. Organic fertilizers, such as cottonseed meal and laying mash, may be eaten directly by fish. Hogan (1933) reported that young bass ate cottonseed meal, and bream have been observed eating cottonseed

meal and laying mash at this Station. Some fishermen throw laying mash about their lines to attract fish. The stomachs of bream caught under such conditions have been found to contain this material. The organic matter of these materials is eaten directly by some of the zooplankton organisms; it is utilized also by the bacteria that are used for food by many of the zooplanktonts, as was pointed out by Meehean (1933, 1935). The organic matter of cottonseed meal and laying mash apparently is not available directly to the more desirable species of phytoplankton. It is probable that the nitrogen, phosphorus, and other minerals do not become available to the phytoplankton until after bacterial decomposition has occurred.

When inorganic fertilizers are used, the nitrogen, phosphorus, potassium, and other elements present are in a form readily available to the green plants constituting the phytoplankton. As a result, relatively heavy growths of phytoplankton may develop following the use of inorganic fertilizers. It has been indicated already that phytoplankton normally is not eaten by game and pan fish. Although it is eaten by some forage minnows and by various insect larvae and some of the larger zooplanktonts, it is probable that the bulk of the phytoplankton must be utilized by bacteria before it reaches a stage utilizable by bream. Thus, when the productivities of Ponds 15 and 18 are compared, it is seen that Pond 15 supported approximately 10 more pounds of fish per acre than Pond 18, but that the former had about twice the average plankton production of the latter.

When the productivities of ponds receiving various organic fertilizers are compared, the relationship between average plankton production and carrying capacity may not be positive and proportionate. The fish themselves might throw the relationship out of balance by eating one organic material directly and not eating another; this situation is not inconceivable when cottonseed meal, soybean meal, or laying mash is compared to manure. The nutrient balance of the fertilizing material also affects the relationship between plankton and fish; the carbon-nitrogen ratio of one material might be such that most of the nitrogen would be utilized by the bacteria bringing about the decomposition of the material, whereas that of another material might be such that a considerable amount of nitrogen would be liberated as ammonia and utilized by phytoplankton.

Although the relationship between average plankton production and bluegill bream production may not be proportionate when various organic fertilizers are used, the trends may be in the same direction. For example, Pond 4 had an average plankton production of 7.8 p.p.m. organic matter and a carrying capacity for bluegill bream of 295.4 pounds per acre; Pond 6 had 10.6 p.p.m. and 451.8 pounds; and Pond 18 had 15.4 p.p.m. and 578.8 pounds.

It is interesting to note that the addition of superphosphate to cottonseed meal doubled the average plankton production and increased the carrying capacity for bluegill bream by four-fifths. The increased

fish production resulting from the addition of superphosphate agrees with the results of Davis and Wiebe (1930), and Hogan (1933). The increase in average plankton production explains, at least partially, the frequently observed increase in fish production following the addition of superphosphate to organic fertilizers.

Although algae did not always form the major part of the plankton in ponds in which organic fertilizers were used, they always were present regardless of the source of the fertilizer.

## Literature Cited

Davis, H. S. and A. H. Wiebe

1930. Experiments in the culture of the black bass and other pondfish. Report, U. S. Commissioner of Fisheries, fiscal year 1930, Appendix IX, pp. 177-203.

Hogan, Joe

1933. Experiments with commercial fertilizers in rearing largemouth black bass fingerlings. Trans. Am. Fish. Soc., 1933, Vol. 63, pp. 110-119.

Meehean, O. Lloyd

1933. The role of fertilizers in pondfish. Trans. Am. Fish. Soc., 1933, Vol. 63, pp. 103-109.

1935. The dispersal of fertilizing substances in ponds. Trans. Am. Fish. Soc., 1935, Vol. 65, pp. 184-188.

Smith, E. V. and H. S. Swingle

1939. The relationship between plankton production and fish production in ponds. Trans. Am. Fish. Soc., 1938, Vol. 68, pp. 309-315.

Swingle, H. S. and E. V. Smith

1939a. Fertilizers for increasing the natural food for fish in ponds. Trans. Am. Fish. Soc., 1938, Vol. 68, pp. 126-134.

1939b. Increasing fish production in ponds. Trans. Fourth N. Am. Wild life Conference, 1939, pp. 332-338.

# METHODS OF COLLECTING OYSTER SPAT

PAUL BONNOT

*California Division of Fish and Game*
*San Francisco, California*

ABSTRACT

An important phase of the program for the rehabilitation of the once prosperous oyster industry of California has been the development of more efficient collectors for taking natural larvae to be reared on artificial beds. Two exceptionally efficient types of collectors were developed. Their increased efficiency was due to the fact that larvae set on both the upper and lower sides of their horizontal surfaces. Older types of collectors ordinarily take larvae in abundance only on the lower sides of horizontal surfaces.

---

From 1870 to 1900 the California oyster industry was a prosperous affair, based on eastern oysters (*Ostrea virginica*), shipped as seed and grown to maturity in San Francisco and Tomales Bays. About 1900 some factor or factors of the natural environment were altered. The old type of oyster grower conducted his operations by trial and error, maintaining no record of environmental conditions. We therefore have no means of knowing how present conditions differ from those which originally prevailed. Although the nature of the changes were not apparent they were of sufficient importance to prevent the growth and maturing of oyster seed. As a result, the industry nearly disappeared. From 1910 to 1931 the industry consisted of importing native or Olympia oysters from Puget Sound for immediate use, and adult eastern oysters, to be held in San Francisco and Tomales Bays until sold.

In 1931 the present program of oyster culture was inaugurated. As we were faced with the problem of creating a fishery rather than with the investigation of one already established, it was considered advantageous to distribute our efforts among several lines of endeavor. The program that was drawn up had three distinct phases. First, an attempt was made to grow eastern oysters from imported seed; second, the seed of Japanese oysters (*O. gigas*) was introduced into some bays and inlets; and third, the culture and commercial production of the native or Olympia oyster (*O. lurida*) were undertaken.

Water temperatures on the Atlantic Coast fluctuate over a much greater range than do those of the West Coast. The eastern oyster is accustomed to a summer temperature of 30° to 35°C., while subzero conditions prevail during the winter. During the summer season temperatures of the water on the West Coast reach 25°C. only occasionally, and during the winter they seldom fall below 5°C. We have found that seed oysters from the more northern localities on the Atlantic Coast, where the water summer temperatures more nearly ap-

proximate those of the West Coast, can be grown in California waters successfully. An increasing quantity of these locally matured oysters is being sold yearly.

The Japanese oyster, in its native habitat, is accustomed to much the same range of water temperatures as the eastern oyster. However, this species is very hardy and will grow rapidly under very adverse conditions. No difficulty has been encountered in growing it from seed. Because of the high temperatures in the winter the Japanese oysters do not hibernate but continue growing during that period. We have been able in one experiment to put these oysters on the market eight months after planting the seed. A period of three years would be necessary in Japan to bring them to a comparable size.

Only exceptionally do the eastern oysters spawn in local waters and no set has been obtained. The Japanese oyster spawns readily but so far the swimming larvae have never reached the growth stage necessary for setting. The absence of one or more organisms in the food chain appears to be the inhibiting factor.

The Olympia oyster is an indigenous species and therefore presents fewer obstacles to successful culture. It has an extensive local consumption and brings a much higher price than do the other species. In view of these facts we have devoted the larger portion of time and effort in an endeavor to cultivate the native form. Humboldt Bay, which has several extensive natural beds of these oysters and large areas free from pollution, was selected as the logical locality in which to proceed with this phase of the program. Several private companies have built artificial beds in Humboldt Bay by hardening the bottom with sand and gravel and surrounding these areas with wooden dikes to maintain from 4 to 6 inches of water over them at low tide. These beds have been planted with seed oysters caught on artificial collectors laid out at the proper time in proximity to the natural beds.

Although we speak of oyster culture, oysters cannot be included in the same category as many so-called domesticated animals. The life history of oysters is well known but they cannot be propagated artificially and their natural environment does not lend itself readily to human manipulation. In common with all organisms in a natural environment the oyster population is maintained in a state of equilibrium by the counter-balancing effects of favorable and unfavorable conditions. The fecundity of oysters is enormous and the destructive potentialities of the natural checks to an increase in abundance are therefore correspondingly large.

We cannot increase the oyster population by purely artificial means, but so abundant are the swimming larvae that if we are able to suppress partially some inhibiting factor or factors an enormous number can be saved that otherwise would die. One of the most obvious checks is the lack of sufficient surfaces to which the swimming larvae can attach themselves. On a natural bed this surface which consists of the dead shells of previous generations of oysters, more or less buried

in the mud and covered with silt and marine growths, is by no means adequate to the setting of all the larvae. To alleviate the loss we offer an extensive surface of some clean, hard material on which the larvae may set. This material should be placed in the water as near the setting time as possible in order to avoid the accumulation of silt or the growth of other organisms.

In the past many materials have been used for this purpose with varying success. The Romans used oyster shells and twigs, the French used a curved tile covered with cement and sand and the Japanese use bamboo sticks, tarred rope and clean shell strung on wires.

It is important to determine the proper time at which to place the collecting surfaces in the water. So far, our knowledge is not extensive enough to enable us to determine this time in advance. The native oyster spawns when the water temperature reaches a minimum of 13°C., but spawning and setting apparently are controlled by different combinations of environmental factors. We have extensive data relating to temperature, salinity, pH, rainfall and tidal heights and cycles, but we have been able to obtain only occasional and uncertain correlation between some combinations of these factors and the cycles of setting. One point, however, seems fairly well established. The water temperature is undoubtedly the agent that sets off the reaction when an optimum combination of the other factors has been attained.

We have been more successful in our endeavors to develop spat collectors of high efficiency, than in predicting when to use them. The first collectors were the paper separators of the type used in egg crates, dipped in a mixture of cement and sand. They were fairly successful on a hard bottom but where there was much silt, or where the bottom was soft, the cells filled up with mud, thus lowering the collector's efficiency. As the larvae swim upside down, with the foot uppermost, it has been found that the majority of spat is taken on the under side of a horizontal surface, progressively smaller numbers appearing on vertical and upper horizontal areas. To offset the disadvantages of the regular egg-crate fillers, Hopkins (1937) developed the "government collector." This collector consists of a paper unit of two rows of seven cells each. The cells are of the same height and width but are twice as long as those of the egg-crate filler. The shape of this collector causes it to lie on its side with the result that most of its surface is presented horizontally. The "government collector" is adapted particularly well for shallow water.

In 1936 an experiment with ply-wood collectors was carried out in Humboldt Bay. From a local manufacturer were obtained units which are known as lettuce-crate tops. These units consist of five strips of thin ply-wood, each 2½ by 22 inches, spaced 1 inch apart, and stapled at the ends to cross pieces which are 1 by ¾ inch. These collectors were dipped in a mixture of cement and sand and were fastened together in sets of five or six, one above the other, so that a

maximum horizontal surface was obtained. The surfaces of the assembled collectors were separated by a distance of three-quarters of an inch. A current of water flowing through these narrow spaces between the rough, uneven cemented surfaces will roll and eddy. Consequently any swimming spat that may be present will be tumbled and whirled, and thus be more likely to come into contact with both the upper and lower surfaces. The scouring action of this turbulent current also keeps the surfaces free from silt. The results obtained by the use of this collector differed greatly from those of previous experiments in spat collecting. The lower horizontal surfaces obtained an average set of sixty-seven larvae per square inch, which catch was excellent in itself, but in addition the upper surfaces, seldom considered as a catching area, took an average of ninety-eight

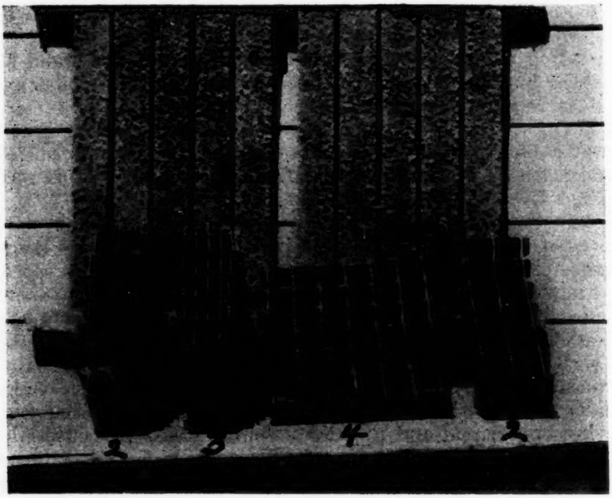


Figure 1.—Various types of oyster spat collectors: (1) two sections of lettuce crate top; (2) the government collector; (3) the modified government collector; (4) the regular egg-crate collector.

larvae per square inch. The logical explanation of this unusual phenomenon would seem to be that in the turbulent water between the surfaces the slight pull of gravity caused more of the swimming spat to fall on the usually silted, but in this collector, clean surface below them.

One difficulty has developed in connection with the use of this collector. Tiny wood fibers of the rough ply-wood are embedded in the

cement coating with the result that the removal of the cement with the attached oysters has proved to be a slow and costly operation. As an adult native oyster is roughly the size of a silver dollar it can be seen readily that only two or three of them can be grown to any size on a single square inch of surface. They must be separated, therefore, before they begin to become crowded.

As the spacing between the layers in the ply-wood collector seems to have been the deciding factor in its efficient operation we have modified the government collector to embody this desirable feature. As our modified collector is made of paper it can be broken up readily after the larvae have set. The cells of the government collector are 1¾ inches square. By inserting two more horizontal sheets we obtain five horizontal surfaces approximately three-quarters of an inch apart.

A study was made during 1938 of the relative efficiency of all the collectors in present use. (See Figure 1 for photographs of the different collectors.) Expressed in relative percentages they rank as follows:

| | |
|---|---|
| Lettuce-crate collector | 6.7 |
| Modified government collector | 5.7 |
| Egg-crate collector | 4.0 |
| Government collector | 0.3 |

These results indicate that the two most efficient collectors are the lettuce-crate and the modified government collectors. The lettuce-crate collector has the disadvantage of being difficult to break up. The modified government collector costs too much at present. Experiments are now being conducted in an attempt to obtain some satisfactory combination of wood and cement, or a cement mixture that will separate more easily from the wood several months after the set has been taken.

## Literature Cited

Hopkins, A. E.
1937. Experimental observations on the spawning, larval development, and setting in the Olympia oyster, *Ostrea lurida*. Bulletin, U. S. Bureau of Fisheries, Vol. 48, pp. 439-503.

# PARASITES OF NORTHERN PIKE AND PICKEREL

George W. Hunter, III
*Wesleyan University, Middletown, Connecticut*
AND
J. Stewart Rankin, Jr.
*Amherst College, Amherst, Massachusetts*

## Abstract

**The parasitic fauna of the northern pike and two species of pickerel (*Esocidae*) from a Connecticut lake has been investigated. Two species of trematodes, two of tapeworms, one each of roundworms, spiny-headed worms, protozoa and parasitic crustacea are reported. The infestation of the Connecticut Lake *Esocidae* is compared with that of the same species from other localities.**

## Introduction

It is well known that many species of fishes thrive when transferred to new habitats. Furthermore it is recognized that introductions of exotic species, regardless of whether or not they occurred accidentally, often result in an extension of the range of that particular species of fish. However, comparatively little is known and recorded concerning the various groups of parasites that have unwittingly (and usually unintentionally as far as man is concerned) accompanied the host when it has been introduced into new environments.

During recent years, in some states at least, northern pike and pickerel have been transferred from the nets of commercial fishermen to new localities, and utilized for the stocking of lakes and ponds. Consequently, it was felt desirable to present the data collected on the various groups of parasites found in and upon those species. Since little is known concerning the parasites of fishes of New England, a "typical" lake, Lake Pocotopaug at East Hampton, Connecticut, was selected as a source of host material. Attention was directed to the identification and distribution of the parasites found on and in the chain pickerel, *Esox niger;* the mud pickerel, *E. americanus;* and the northern pike, *E. lucius.*

## Parasites of Lake Pocotopaug Esocidae

Much has been recorded concerning the voracity of the pickerel in general and the northern pike in particular. Consequently one might expect to find evidence of dietary variation if their food were studied. That such expectations are not unwarranted may be seen from an account of the food of pickerel taken from this same lake (Hunter and Rankin, 1939). As a corollary to the above one might also expect to discover a wide diversity of intestinal parasites that had been brought in with the food of the northern pike and pickerel. This study

reveals that all pickerel over 9 centimeters in length were hosts to various species of parasites and that the larger and older the fishes were, the greater was the degree of parasitism.

It should be noted that altogether a total of eleven *Esox americanus,* eleven *E. lucius,* and thirty-seven *E. niger* were examined from Lake Pocotopaug. While the collections do not represent sufficient numbers for the purposes of statistical analyses, they probably provide a fairly accurate picture of the species of parasites present in these fishes in Connecticut. Van Cleave and Mueller (1934) did not state the numbers of fishes of each species that they examined from Oneida Lake.[1] However, they did record a greater variety of parasites than noted here. Hunter and Hunter (1930, 1931, 1932, 1934) studied a total of 6 *E. americanus,* 147 *E. niger,* and 67 *E. lucius* from other regions of New York State, thus supplementing the data furnished by Van Cleave and Mueller and furnishing a fairly accurate record of the parasites present that may serve as a basis for comparison with the data on the Esocidae from Lake Pocotopaug.

The northern pike and two species of pickerel that were examined from Connecticut sheltered one species of protozoa, two of trematodes and tapeworms, and one each of roundworms, spiny-headed worms and ectoparasitic crustacea as listed below (immature forms are designated by asterisks):

**Esox niger**

Common: *Azygia angusticauda; Macroderoides flavus.*
Occasional: *Proteocephalus pinguis; Trichodina renicola.*
Rare: *Proteocephalus ambloplitis;** Spiruridae;* *Argulus versicolor.*

**Esox americanus**

Common: *Macroderoides flavus; Azygia angusticauda.*
Occasional: *Proteocephalus pinguis; P. ambloplitis;** *Trichodina renicola.*
Rare: Spiruridae.*

**Esox lucius**

Common: *Azygia angusticauda.*
Occasional: *Proteocephalus pinguis.*
Rare: *Proteocephalus ambloplitis;** Spiruridae.*

The degrees of infestation denoted above have the following percentage values: abundant, 85 to 100; common, 50 to 84; occasional, 10 to 49; and rare, 0.1 to 9.

THE PROTOZOA

*Trichodina renicola*—This relatively large protozoan parasite was described by Mueller (1931), who found it in the urinary bladder of *E. niger* from Oneida Lake, New York. In Connecticut it was found

[1]It should be noted that Van Cleave and Mueller had no data on *E. americanus.*

in 13.5 per cent and 45.4 per cent of the *E. niger* and *E. americanus* respectively. When infection occurred it frequently extended into the kidneys, as great numbers of parasites were present.

THE PARASITIC WORMS

*Macroderoides flavus*—This small intestinal trematode was encountered in 67.5 and 81.8 per cent of the *E. niger* and *E. americanus*, respectively, taken from Lake Pocotopaug. These parasites were found along the entire length of the intestine but were especially plentiful in the lower one-third. Generally speaking more than ten parasites of this species were found in a single fish, infection with less being rare. Van Cleave and Mueller (1934) recorded this same parasite from *E. niger* taken in Lake Oneida, New York. It was found infrequently by Hunter (unpublished data) in Esocidae from other parts of New York State.

*Azygia angusticauda*—Trematodes of this species were characteristically located in the stomach of the host. They occurred in all three species of *Esox* from this lake and were present in 54.5, 67.5, and 81.8 per cent respectively of the *E. lucius, E. niger* and *E. americanus*. Van Cleave and Mueller (1934) reported them as occasional parasites in *E. niger* only. This parasite, however, occurred in both *E. niger* and *E. lucius* in the northern regions of New York (Hunter, unpublished records).

*Proteocephalus pinguis*—This tapeworm is one of the more common cestodes of northern pike and pickerel. It lies with its head, or scolex, attached to the upper part of the intestine and was found in 36.4, 18.9, and 18.1 per cent of the *E. lucius, E. niger*, and *E. americanus*, respectively, from Lake Pocotopaug. *Proteocephalus pinguis* was listed by Van Cleave and Mueller (1934) as "abundant" in *E. lucius* and "common" in *E. niger* from Oneida Lake. This tapeworm was quite common in these fish in New York (Hunter and Hunter, 1930, 1931, 1932, 1934; Hunter, 1932).

*Proteocephalus ambloplitis*—Tapeworms of this species were encountered only as plerocercoid larvae and were recovered from the liver and more occasionally from other organs of the viscera. They occurred in 18.1, 8.1, and 8.1 per cent, respectively, of the *E. americanus, E. lucius*, and *E. niger*. Van Cleave and Mueller (1934) found this form only in *E. niger*, while the host records of the senior author indicated the presence of *P. ambloplitis* larvae occasionally in *E. lucius* as well as *E. niger*.

Spiruridae—Nematodes of this family were found in the body cavity of 8 or 9 per cent of all three species of pickerel that were studied.

*Leptorhynchoides thecatus*—This form was encountered only in the great northern pike and then in only 9 per cent of the specimens examined. Van Cleave and Mueller (1934) found it in both *E. lucius* and *E. niger*. It likewise was encountered frequently by Hunter and

Hunter (1930, 1931, 1932, 1934) in both of these host species from other parts of New York.

THE CRUSTACEA

*Argulus versicolor*—This ectoparasitic crustacean was not common; it was found on only 8.1 per cent of the *E. niger* that were examined. It was not reported by Van Cleave and Mueller (1934).

## DISCUSSION

Some of the most recent data concerning the distribution of fresh-water fish parasites were obtained by Van Cleave and Mueller (1934) and Bangham and Hunter (1939). The former studied Oneida Lake over a period of several summers and found and recorded a greater number of parasites than are listed for Connecticut. Hunter (1932), Hunter and Hunter (1930, 1931, 1932, 1934) likewise indicated that a wider variety of parasites are ordinarily found in the several species of *Esox* from various parts of New York. Bangham and Hunter (1939) also found a greater variety of parasites in fishes of Lake Erie than were found in those from Connecticut.

For the sake of completeness, the various species of parasites reported by Van Cleave and Mueller or by Hunter and Hunter for the *Esox* of New York State that have *not* been found in the same species of fish from Connecticut follows (immature forms are designated by an asterisk):

**Esox americanus**

Trematodes: *Crassiphiala bulboglossa.**

**Esox niger**

Trematodes: *Uvulifer ambloplitis** (?)[2]; *Diplostomulum scheuringi;* Crassiphiala bulboglossa;* Microphallus ovatus; Bucephalus elegans.*

Nematoda: *Spinitectus gracilis; Heduris tiara.*

Acanthocephala: *Neoechinorhynchus cylindratus; N. tenellus; Leptorhyncoides thecatus.*

Annelida: Leech.

**Esox lucius**

Trematodes: *Crassiphiala bulboglossa;* Uvulifer ambloplitis* (?)[2]; *Phyllodistomum superbum* (?); *Centrovarium lobotes; Macroderoides flavus; Plagiocirrus primus.*

Nematodes: *Tetraonchus moncnteron; Spinitectus gracilis.*

Cestodes: Pseudophyllidea.

Acanthocephala: *Neoechinorhynchus cylindratus; Pomphorhynchus bulbocolli.*

---

[2]Reported only by Van Cleave and Mueller (1934).

From the above lists it is quite apparent that the fishes taken west of the boundary of New England have a more varied parasitic fauna. This greater diversity is probably correlated with the changes that occurred during the last glacial period.

## Literature Cited

Bangham, R. V., and G. W. Hunter, III.
1939. Studies on fish parasites of Lake Erie. Distribution studies. Zoologica, Vol. 24, pp. 385-448.

Hunter, G. W., III.
1932. An artificial lake with a low percentage of infected fish. Trans. Amer. Misc. Soc., Vol. 51, pp. 22-27.

Hunter, G. W., III, and Wanda S. Hunter.
1930. Studies on the parasites of fishes of the Lake Champlain watershed. A Biological survey of the Champlain Watershed. Suppl. 19th Ann. Rept., N. Y. St. Conserv. Dept., 1929, pp. 241-260.
1931. Studies on fish parasites in the St. Lawrence watershed. A biological survey of the St. Lawrence watershed. Suppl. 20th Ann. Rept. N. Y. St. Conserv. Dept. Biol. Surv. No. V, 1930, pp. 197-216.
1932. Studies on parasites of fish and of fish-eating birds. A biological survey of Oswegatchie and Black River systems. Suppl. 21st Ann. Rept. N. Y. St. Conserv. Dept. Biol. Surv. No. VI, 1931, pp. 252-271.
1934. Studies on fish and bird parasites. A biological survey of the Raquette Watershed. Suppl. 23rd Ann. Rept. N. Y. St. Conserv. Dept. Biol. Surv. No. VIII, 1933, pp. 245-254.

Hunter, G. W., III, and J. S. Rankin, Jr.
1939. The food of pickerel. Copeia No. 4, pp. 194-199.

Mueller, J. F.
1931. A new species of Cyclochaeta from the ureters and urinary bladder of *Esox reticulatus*. Jour. Parasitol., Vol. 18, p. 126.

Van Cleave, H. J., and J. F. Mueller.
1934. Parasites of Oneida Lake Fishes. Part III. A biological and ecological survey of the worm parasites. Roosevelt Wild Life Annals, Vol. 3, pp. 161-334.

# *NEASCUS* INFESTATION OF BLACK-HEAD, BLUNT-NOSED, AND OTHER FORAGE MINNOWS[1]

George E. Klak

*U. S. Bureau of Fisheries, Leetown, West Virginia*

Abstract

**Black-head, blunt-nosed, and other minnows were found infested with encysted flatworms in ponds at Leetown, West Virginia. The mortality in a 2.2-acre pond stocked with 100,000 black-head minnows was about 250 per day during four weeks of observation. Heavy infestations caused sterility in the minnows. The cyst and parasite are described briefly and the probable life cycle given, followed by certain recommendations for the control of the infestation.**

## Nature of the Infestation

Minnows under certain conditions may become heavily parasitized with flatworms. So severe may this infestation become that entire lots of forage minnows may be destroyed. Of the five species of minnows examined, only the golden shiners, *Notemigonus crysoleucas,* were free from infestation. Black-head minnows, *Pimephales promelas,* and blunt-nosed minnows, *Hyborhynchus notatus,* were most severely parasitized. Spot-tailed minnows, *Notropis hudsonius,* and attractive minnows, *Notropis amoenus,* carried minor infestations.

A parasitic infestation was first noted on June 29, 1938, when about 300 dead black-head minnows were found on the surface of a pond at the U. S. Bureau of Fisheries Station at Leetown, West Virginia. Examination of the fish indicated that death was caused by severe infestations with encysted flatworms that were visible to the naked eye. The oval-shaped cysts enclosing the folded flatworms were found in the abdominal cavity of the fish. In heavy infestations, such as shown in Figure 1, the pressure created by the cysts caused them to flow out from the body cavity with a yellow fluid when the fish was opened.

The daily mortality in the lot of 100,000 black-head minnows was about 250 per day during four weeks of observation. For several days prior to death the minnows were inactive, manifested a tendency to rest on the bottom, and behaved in general, as if exhausted from moving their heavy bodies swollen with worms. External lesions were present on the abdominal walls of minnows that were so filled with worms that internal pressure was created (Figure 2). At first it appeared that the body was filled with eggs, but that was not true. Of the 136 females examined only 4 had eggs in their ovaries. This

[1]Appreciation is expressed to Mr. Eugene W. Surber, in charge, Leetown Station, and to Dr. H. S. Davis, in charge, Aquicultural Investigations, U. S. Bureau of Fisheries, for helpful suggestions and criticisms. Published with the permission of the Commissoner of Fisheries.

finding seemed to indicate that the presence of parasites inhibited or prevented formation of eggs, which was further substantiated when the pond was drained and no young minnows were found. The

Figure 1. Encysted worms released from the body of a black-head minnow.


Figure 2. Black-head minnows swollen with encysted worms and showing an abdominal lesion caused by the pressure of the worms.

stomachs of the largemouth black bass fingerlings from the same pond contained no minnow fry. All evidence, therefore, pointed to the fact that heavy infestations with the parasitic worms produced sterility in the black-head minnows.

In the lot of 100,000 black-head minnows where the condition was first observed, the infestation was probably 100 per cent. All individuals in a random sample of 152 minnows were infested. So extreme was the infestation per fish that a Sedgwick-Rafter counting cell was used in order to determine the number of parasites. The number of worms per black-head minnow varied between 674 and 3,712, and averaged 1,752. These figures are from a random sample of ten individuals. In maximum infestations each minnow harbored over 12,000 parasites.

## The Probable Life Cycle of the Parasite

From present knowledge, it appears that the parasite is an encysted metacercarian belonging to the trematode (flatworm) family Strigeidae and the genus *Neascus*. A careful review of literature to determine the species of the metacercarian under consideration has been made. It appears that the organism is an undescribed species. It is possible that the adult or one or more of the intermediate stages have been described previously. Complete identification or a new description of *Neascus* sp. will be reported after the details of the life cycle are determined.

The life history of this parasite probably follows in general the cycle as worked out for other members of the group. The adult worm develops in the digestive system of fish-eating birds. Eggs laid inside the body of birds are deposited with droppings into the water of ponds. The eggs hatch into miracidia that penetrate snails where they result in the formation of thread-like sporocysts, which give rise to daughter sporocysts, and these in turn to cercariae. The cercariae doubtless are fork-tailed and enter the minnows by boring through the body wall, lose their tails, encyst, and undergo metamorphosis into *Neascus* larvae. The larvae (metacercariae) enter the final host (fish-eating bird) by being eaten with the minnow in which they are encysted. Thus, snails and minnows are believed to serve as intermediate hosts for the parasites, and fish-eating birds as final hosts in which the adult worms develop.

Certain observations have been made on the development of the metacercariae. In minnows examined on June 29, 1938, 32.0 per cent of the larvae were not encysted. Many of these were small, measuring from 0.41 to 0.73 millimeter (average 0.63 millimeter) in length, and appeared immature. When the same lot of minnows was examined four weeks later, all of the larvae were encysted and measured 1.28 millimeters (average) in length. It appears that the *Neascus* larvae described by other workers as being without cysts were immature forms.

In minor infestations—those that do not kill the minnows—the encysted larvae persist in the body cavity of the fish for a relatively long time. Black-head minnows from the original infected lot were kept in an aquarium for a period of ten months with no change in the degree of infestation.

Examination of snails, which are extremely abundant in the ponds, indicated the presence of sporocysts. Fifteen species of fish-eating birds and twenty-two species of birds that may occasionally eat fish have been recorded at the ponds. The bass ponds in which the material for this study was collected have "feather edges." The shallow water areas are invaded by large numbers of killdeers, a few greater and lesser yellow legs, and other shore birds. Kingfishers, green herons, and black-crowned night herons also occur in numbers and have been observed feeding on fish many times at these ponds. The water level of the pond in which the mortality among the black-heads was first noted was unusually low during the 1938 season due to a water shortage. The low level resulted in an unusually wide expanse of very shallow water which was attractive to shore birds. While kingfishers, green herons, and black-crowned herons normally would be suspected to be the final hosts of the adult parasites, killdeers and possibly other shore birds are strongly suspected of being additional hosts. Killdeers actually were observed eating black-head minnows.

## Description of the Cyst

The cyst is always considerably shorter than the enclosed parasite causing the anterior end of the worm to be folded on itself dorsally or ventrally. In heavy infestations, the cysts are found in clusters of variable numbers, two or three to as many as fifty cysts in each cluster, held together by transparent strands. Most of the individual cysts or clusters of cysts are free in the body cavity of the fish and can be removed readily by a stream of water from a pipette. Some of the cysts, however, appear to be attached to the viscera by the transparent strands. Cysts that contained living parasites, and were not subjected to pressure by a superimposed cover glass, varied in length from 0.76 to 1.02 millimeters (average 0.87 millimeter), and in width from 0.44 to 0.52 millimeter (average 0.47 millimeter).

## Description of the Parasite

The body of the parasite is divided by a constriction into two well-defined regions, the fore- and the hind-bodies. The fore-body is about twice as long and somewhat wider than the hind-body, is relatively thin, elliptical in outline, and clearly spoon-shaped with the ventral surface concave. Its shape, however, is variable in accordance with the activity of the parasite. It may become thick and wide when contracted, or thin and ribbon-like when elongated.

The parasites within the cysts usually are in motion, slowly length-

ening and contracting their fore-bodies. When removed from the cysts, the parasites persist in their leech-like movement, but accomplish no definite locomotion such as has been observed in some of the other species of *Neascus*. The parasites remained active in their cysts for several days after they were removed from the fish. They were also active in the bodies of minnows which had been dead for two days and had started to disintegrate. In a 5 per cent solution of glacial acetic acid they emerged from their cysts but remained alive for about four hours.

Various measurements of fixed and living parasites have been made in which considerable variations existed depending upon the condition of contraction or extension at the time of measurement, state of growth, and the nature of the fixing solution used. Living parasites removed from cysts and, not subjected to cover-glass pressure when at rest, varied in length from 0.81 to 0.89 millimeter (average 0.86 millimeter). Parasites fixed in 4.0 per cent formalin varied in length from 1.09 to 1.42 millimeters (average 1.28 millimeters). Figure 3 shows encysted and liberated parasites in which some of the prin-

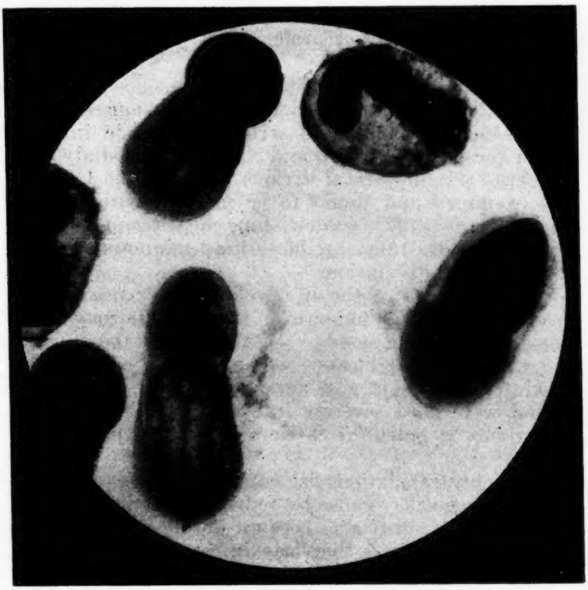

Figure 3. Encysted and liberated flatworms in which some of the principal structures may be discerned.

cipal organs may be discerned, notably the spoon-shaped fore-body and the rounded hind-body, the acetabulum, the oral sucker, and the vessels of the excretory system. In living parasites, the granules present in the excretory vessels surge back and forth as the animal contracts and extends.

## Host-Parasite Specificity

Of the seven species of fish examined, three species are immune and do not become infested with the *Neascus* parasite under consideration.

The principal food of the smallmouth black bass fingerlings consisted of black-head minnows. The minnows, inside the stomachs of the fingerlings, were parasitized, but the bodies of the bass were free from infestation. None of the largemouth black bass from ponds that contained parasitized black-head minnows were infested with the larvae. The golden shiners removed from another pond were not infested, but several black-head minnows found with the golden shiners were infested. Blunt-nosed, spot-tailed, and attractive minnows were similarly infested with the *Neascus* parasite. Hence, of the seven species of fish examined, smallmouth and largemouth black bass and golden shiners apparently have a natural immunity and do not become parasitized with these metacercariae.

## Conclusions

The observations on host-parasite specificity suggest that a species of minnow which is immune to serious trematode infestation may be used as a forage or bait minnow. During this study several hundred black-head minnows from various ponds at the Leetown Station have been examined and found to be infested with the trematodes. As a result of this study golden shiners, *Notemigonus crysoleucas*, probably will be substituted for black-head minnows as forage fish in the pond culture at this station.

Since the completion of the life-cycle of the parasite requires the presence of snails, the abundance of the parasite may be controlled by winter-drying of the ponds. In this study the infestation was studied in various ponds, but one which was full of water during the previous winter had the largest number of snails, hence the minnows in that pond were most severely infested. Snails should be considered at all times as potential carriers of various parasites that may infest fish.

At most fish-cultural stations fish-eating birds are controlled because of the direct damage they cause by reducing the numbers of fish. The birds should be controlled also because of the indirect damage they cause by carrying parasites that may infest entire lots of fish.

Parasitized minnows should not be distributed to lakes and streams nor should they be used for bait because they may be eaten by birds and thus spread the infestation over a wide territory.

# SALMONOID FISHES IN THE ARGENTINE ANDES

FRED A. THOMPSON

*Department of Game and Fish, Santa Fe, New Mexico*

ABSTRACT

Trout were introduced into Argentina before 1900 but the actual successful establishment of trout and salmon occurred subsequent to 1903. Of the twelve different species of fish imported, only four reproduced successfully and became acclimatized. The site of the principal introductions of salmonoid fish was the National Park of Nahuel Huapí which is well-suited for trout. The mountains are high and well covered with vegetation. Most of the streams are short and have considerable volume and velocity.

Several lakes and streams were examined by the author during 1937 to determine their value for fishing and for the collection of spawn. Data were secured during the 1937 spawning season on the weight and length of the landlocked Atlantic salmon (*Salmo salar sebago*) and the brook trout (*Salvelinus fontinalis*). Information also was obtained on the size and abundance of the various species of trout and salmon.

Due to the apparent decline in the fish population a fisheries station was constructed in 1932 in order to assist in maintaining the stocks. However, because of unfavorable water conditions a new hatchery building and ponds were constructed in 1937. The species to be propagated at this station are brook trout (*Salvelinus fontinalis*), rainbow trout (*Salmo irideus*), German brown trout (*Salmo fario*), and landlocked Atlantic salmon (*Salmo salar sebago*).

Some projects designed to develop the fisheries were undertaken and many more were planned or recommended.

## INTRODUCTION

It is the purpose of this paper to discuss the establishment and the present status of the culture of the salmonoid fishes in Argentina. An agreement was made between the Administration of National Parks of Argentina and the Division of Fish Culture whereby the former was to employ a technical advisor to cooperate with the latter to construct a fish hatchery, to take charge of all fish-cultural operations, to instruct the hatchery personnel, and to make stream and lake surveys. It was my privilege to participate in this program as technical advisor during 1936 and 1937.

## INTRODUCTION OF THE SALMONOID FISHES INTO ARGENTINA

The following historical resumé of the introduction of the salmonoid fishes into Argentina was condensed from the publications of Tulian (1910) and Marini (1936). Salmonoid fishes were first introduced into Argentina prior to 1900 when a lot of rainbow trout (*Salmo irideus*) was placed in Hurlington Creek; there is no record of their survival. Shortly after 1900 investigations were initiated by the Minister of Agriculture of Argentina to determine what localities

were suitable for the introduction of salmonoid fishes. The Minister was not convinced by the investigations made by the one man then in his services, and instructed the Argentine Ambassador to the United States to employ John W. Titcomb to organize a division of fish culture, to study the waters of Argentina, and to culture indigenous species of fishes. On January 19, 1904, E. A. Tulian left New York with a shipment of eggs destined for the hatchery site on the shores of Lago Nahuel Huapí. Subsequent shipments of eggs for stocking this lake were made in 1904, 1905, and 1931. Other shipments which were made to Argentina in 1906, 1908, 1909, and 1910 were consigned to waters in other parts of the country.

The following numbers of eggs were imported into Argentina between the years 1904 and 1931, according to the records published by Marini (1936):

| | |
|---|---|
| Brook trout (*Salvelinus fontinalis*) | 587,700 |
| [1]Rainbow trout (*Salmo irideus*) | 422,000 |
| [1]Steelhead (*Salmo gairdnerii*) | 320,000 |
| Lake trout (*Cristivomer namaycush*) | 507,000 |
| German brown trout (*Salmo fario*) | 181,000 |
| Landlocked Atlantic salmon (*Salmo salar sebago*) | 215,000 |
| Whitefish (*Coregonus clupeaformis*) | 1,000,000 |
| Quinnat salmon (*Oncorhynchus tschawytscha*) | 1,100,000 |
| Sockeye salmon (*Oncorhynchus nerka*) | 426,500 |
| Silver salmon (*Oncorhynchus kisutch*) | 388,200 |
| Atlantic salmon (*Salmo salar*) | 45,000 |
| Cod (*Gadus morrhua*) | 3,000,000 |

Marini stated that at least some of all of the shipments of eggs reached Argentina except those of the cod which were lost in England. He also stated that all of the early shipments from the United States were made via Europe because no ships equipped with refrigerated holds were in direct commerce between the United States and Argentina.

Only four of the many species imported have become established and are doing well. They are brook trout, rainbow trout, German brown trout, and the landlocked Atlantic salmon. To the author's knowledge none of the other species has become acclimated.

On February 13, 1937, a shipment of whitefish eggs was received at Bariloche after being en route for twenty-four days. Although the eggs were inspected in New York and found to be in perfect condition, they arrived at their destination in an advanced state of putrefaction. From the two million eggs shipped only 61,000 fry resulted (3.05 per cent).

A shipment of 100,000 rainbow trout eggs arrived from the United States on January 30, 1938. On arrival the eggs were very thin-shelled and nearly all contained a large blood clot. One-half of the

[1]Most ichthyologists now consider *Salmo irideus* Gibbons and *Salmo gairdnerii* Richardson to be the same form and apply the name, *Salmo gairdnerii irideus* Gibbons.

eggs was sent to a hatchery on Córdoba and the other one-half to Bariloche. Only about 300 of the eggs at Bariloche hatched normally and survived.

Both of the above egg shipments were unattended during the time between shipment at New York and their arrival in Buenos Aires, a period of about seventeen days. That fact may have accounted for the poor condition of the eggs at the time of their arrival. Unless transportation is more rapid, or the methods of packing eggs for shipment is improved, it is not advisable to ship eggs over such a great distance without an attendant.

A shipment of 50,000 rainbow trout eggs was received from the Republic of Chile on October 3, 1937. The eggs were in good condition, and were en route less than four days. Less than 5 per cent of the eggs and resultant fry were lost.

## Physiography of the Region

The National Park of Nahuel Huapí is located in the Andes Mountains and includes an area of approximately 3,500 square miles of land and water. The elevation ranges from 2,100 feet at the lakes to 11,000 feet on the highest peak, El Tronador. The mountains are very rugged and in some places extend almost vertically from the valley floor. The vegetation is abundant on the lower slopes and in the valleys. The lake bottoms, like the mountains, have a very steep slope; beaches and shallow water are rare except at the mouths of streams. Most of the streams are rapidly moving with boulder bottoms; this condition is found especially in the feeder streams. However, the streams that originate in lakes flow more slowly and contain varying quantities of natural fish food throughout the year. Of forty major streams observed, five could be classed as excellent habitats for salmonoid fishes and five had abundant natural fish food during nine months of the year. Seven streams retained an average amount of fish food but no vegetation during the winter months. Nine were below average in natural food content as the water moved rapidly with few pools. Five had very little natural food, no vegetation, and the water moved rapidly over boulders. Nine streams had no natural aquatic food, vegetation was absent, and the water flowed in torrents and cascades.

## Abundance, Distribution, and Size of the Salmonoid Fishes

From personal observations and information received from cooperating individuals it was concluded that the salmonoids of this region in the Andes Mountains of Argentina could be classified according to their abundance. The brook trout is most numerous and occurs in large numbers in almost all lakes and streams. However, it is found principally in the lakes and large rivers and enters the smaller streams only during the spawning season. The distribution of the landlocked Atlantic salmon is less general for it is found in only a few places.

It is abundant in the Traful, Limay, and Correntoso Rivers, and is taken regularly in Lakes Nahuel Huapí, Traful, Correntoso, Espejo and occasionally in some of the other lakes. The rainbow trout is confined chiefly to Lake Traful and the Limay and Traful Rivers. The German brown trout is found in several localities but is caught only occasionally. It is most abundant in the Traful River.

During the spawning season of 1937 the lengths and weights of the salmon and brook trout were recorded as the fish were removed from the nets. The lengths of thirty-eight salmon ranged between 46 and 82 centimeters (18.1 and 32.3 inches) and averaged 67.1 centimeters (26.4 inches). Their weights ranged between 2 and 10 kilograms (4.4 and 22.0 pounds) and averaged 6.3 kilograms (14.0 pounds). The lengths of ninety-two brook trout ranged between 27 and 52 centimeters (10.7 and 20.5 inches) and averaged 41.0 centimeters (16.1 inches). The weights ranged between 0.5 and 3.3 kilograms (1.1 and 7.2 pounds) and averaged 2.1 kilograms (4.6 pounds).

The largest salmon reported to have been taken in the park, captured with a seine in Rio Traful, weighed 16.5 kilograms (36.4 pounds) but no length measurement was obtained. Guy Dawson, the owner of Traful Hotel, has a record of a salmon of 12.5 kilograms (27.6 pounds) taken with a spoon, and one of 8.5 kilograms (18.7 pounds) taken on a fly. The largest brook trout recorded was taken in 1937 by commercial fishermen with a seine, and weighed 4.8 kilograms (10.6 pounds).

## Fish-Cultural Developments

The fisheries station, built in 1932, consisted of an eight-trough hatchery, two residences and a garage. Two of the nine adjacent ponds, which measured 25 by 75 feet, were constructed of boards. The water supply came from a small stream, Arroyo Cascada, and was conducted through an open canal. During the winter the water was cold and turbid, in the spring and in the fall it was muddy and full of debris, and during late summer there was insufficient water to maintain even one-half of the ponds.

The first problem confronted by the author on his arrival on October 26, 1936, was to decide on a new location for a hatchery, because of the unsatisfactory water supply at the existing station. After careful consideration of the water temperature and volume of streams, and the precipitation in different localities, a site was chosen on the banks of the Rio Gutierrez about 200 yards from the hatchery on Arroyo Cascada. During the coldest month the average temperature of Rio Gutierrez for the fiscal year 1935-1936 was 6.1°C. (43° F.). There was a limited amount of debris in the water during the run-off period. Because Lago Gutierrez was only 3 miles above the hatchery site, Rio Gutierrez had only a gradual fluctuation of water level. Turbidity was at a minimum and at all times submerged objects were visible at depths of 18 inches or less below the surface. The volume of the water

at its lowest stage was more than adequate for the requirements of the new station. The normal flow exceeded 8 feet per second.

Plans were made for a hatchery building to accommodate forty-eight troughs. Each trough contained seven compartments. Sixteen ponds, of the raceway type, each measuring 6 by 60 feet, were to be constructed on adjacent grounds. Only two ponds were built during the initial construction because of the limited funds available.

Complete plans were made and submitted for a second fish-hatching and rearing station on Rio Guillelmo. This station was to have a hatchery building that would contain only thirty troughs. The ponds were to be circular, utilizing the water pressure created by the 30-foot fall on Rio Guillelmo. The contemplated construction of two additional hatcheries to operate in conjunction with the one at Bariloche did not materialize because of insufficient funds.

With the new hatchery at Bariloche, the facilities of which may be supplemented later by the construction of additional stations, the propagation of the brook trout and the landlocked Atlantic salmon is being continued for general stocking purposes and for introduction into new waters. The author recommended that each species be consigned to a particular body of water. Although the culture of rainbow trout has been restricted, there are several streams suitable for them, and their propagation should be continued. The German brown trout, like the rainbow trout, has received limited attention. Propagation of brown trout should be discontinued because the water conditions of the region are not well suited to them.

Previous to 1937 all of the eggs for artificial propagation were obtained either from brood stock or from fish caught in the rivers with a seine. In 1937 two complete temporary traps were planned and constructed by the author. These traps proved effective in two streams near the hatchery. However, seining for salmon was continued in Rio Traful. Plans were made for a permanent trap structure but the construction was not undertaken. It is necessary to make permanent structures in the streams before fish trapping can be completely successful, because of the rains and the high-water conditions both in the spring and in the fall. The establishment of permanent fish traps was recommended for several streams that were considered to be good spawning streams.

Obstructions were present near the mouth of two streams; one was artificial and the other a natural fall. Plans for a pool-fall type fish ladder were made and submitted by the author so that the fish might pass over the obstructions.

## Future Fisheries

Because of the many lakes in the national park, it has been suggested by the author that the black-spotted trout (*Salmo clarkii lewisi*) common in Yellowstone National Park, in the United States, be introduced. It is relatively certain that the black-spotted trout will repro-

duce rapidly, and in a few years will become one of the outstanding fish of the lake region of the Argentine Andes. The brook trout in the Andes, unlike those of the United States, are poor fighters; therefore, with the introduction of the black-spotted trout the Andean lakes would have a fighting fish comparable to the rainbow trout in the streams.

With the trout and salmon established in nearly all major lakes throughout the region, it is possible to maintain the good fishing. However, there are actually fewer fish now than there were some years ago, before the railroad was built into Bariloche. Since the completion of the railroad the country has become more densely populated and the demand for fish has increased. That demand has not been created by the angler but by the commercial fishermen. Because of the encouragement of commercial fishing on inland waters and because no restrictions as to locality or season are imposed, particularly during the spawning season, the future of the fisheries is uncertain. Recommendations for fishing regulations were submitted by the author to guard against complete depletion of the fish in certain streams. There seem to be only two alternatives that will stop the steady decline of the fish population: the production of sufficient fish in the hatchery for stocking the streams, or the restriction of commercial fishing.

## Literature Cited

Marini, Tomás L.
1936. Los salmónidos en nuestro Parque Nacional de Nahuel Huapí. Ministerio de Agricultura de Argentina, Buenos Aires. pag. 1-24, 4 figs.

Tulian, E. A.
1910. Acclimatization of American fishes in Argentina. Bull. U. S. Bur. Fish. Vol. 28, Part II, 1908, pp. 957-965.

---

## Discussion

Mr. Brian Curtis: Have you any data on the food of the landlocked Atlantic salmon in Argentine streams?

Mr. Thompson: The Argentine lakes in this region are heavily populated with a small fish known to the people there as "pulle." It grows to a length of 2½ to 3 inches. I do not know the scientific name for it, but it is one of the foods. Another is a crustacean, a shrimp, and it seems to be the chief food of the landlocked Atlantic salmon. These two foods are very abundant.

Mr. Leo Shapovalov: Are you in a position to account for the lack of success of the Pacific salmon?

Mr. Thompson: I do not know definitely, but I think perhaps the reason that the Pacific salmon has not become established there is that before most of the streams reach the ocean they are usually too warm to enable the fish to survive. If they are not too warm, as a general rule they are too muddy; they pick up a great deal of debris.

The Chairman: Perhaps it would be well to import some of the forage fish mentioned by Mr. Thompson into this country.

# THE NUMBER OF EGGS AND PYLORIC APPENDAGES AS CRITERIA OF RIVER VARIETIES OF THE ATLANTIC SALMON (*SALMO SALAR*)

David L. Belding

*Boston University School of Medicine, Boston, Massachusetts*

### Abstract

The number of eggs and pyloric appendages in relation to river varieties of the Atlantic salmon is discussed. The average 2-year sea-life female salmon, weighing 10.61 pounds, gives a yield of 8,848 eggs or 834 per pound of fish. When the same sea-life classes of salmon and the number of eggs per pound of fish are used as the basis of comparisons, the difference between the salmon of various rivers with respect to the number of eggs is not sufficiently great to warrant its use for identifying river varieties of salmon in the sea. Similarly the number of pyloric appendages, which averages 55.4, with a range from 40 to 74, is of no practical value for the identification of river varieties of salmon.

## Introduction

If the assumption that most salmon return for spawning to the river where they spent their early fresh-water life is true, it is not unreasonable to believe that heredity and environment eventually may produce distinctive anatomical and physiological characteristics in the salmon of different rivers. Usually the differential characteristics attributed to river stocks are the result of variations in the abundance of the several sea-life classes, particularly of the previously-spawned salmon. Anatomical differences between similar sea-life classes in different rivers are difficult to demonstrate, since there are such wide variations in the salmon of the same river that there is considerable overlapping of the data for salmon of different rivers.

McGregor (1923) was able to detect rather striking differences in the number of eggs and pyloric appendages of the chinook salmon (*Oncorhynchus tschawytscha*) in the Sacramento and Klamath Rivers of California. The present paper contains the results of a similar study on the Atlantic salmon of the Gulf of St. Lawrence. The purpose of the investigation was to determine whether anatomical differences existed between salmon of different streams and, if differences were present, whether they would prove of value in identifying the salmon of the various rivers.

Observations were made upon salmon that were taken from June 15 to September 15, 1930 by drift-net fishing in the coastal waters of eastern New Brunswick and upon salmon that were taken during their upstream migration in the Miramichi River during the same period. The coastal salmon were taken within a radius of 20 miles from the estuary of the Miramichi River. They had reached the coastal waters

in their spawning journey, but had not as yet entered the rivers. They represented a mixture of salmon bound for the Miramichi River and the small rivers of the east coast of New Brunswick and of salmon headed for Chaleur Bay.

The coastal salmon were separated arbitrarily by inspection into two groups: (1) those resembling Miramichi River salmon, and (2) those resembling salmon of Chaleur Bay. Tagging experiments and a statistical study of sea-life classes, river age, length and weight have confirmed the reliability of this method of classification. Hence, the comparison of the number of eggs and pyloric appendages deals with three groups of salmon: (1) Miramichi River salmon, (2) coastal salmon having the general appearance of Miramichi River salmon, and (3) coastal salmon having the general characteristics of the salmon of the rivers of Chaleur Bay.

The number of eggs was obtained by making actual counts on weighed, selected samples of the ovaries and multiplying each count by the ratio of the weighed samples to the total weight of the ovary. The number of pyloric appendages was determined by actual count.

Although statements based on the examination of frequency distributions of certain data will be made throughout the paper, it is believed that the presentation of the actual frequencies would involve an unwarranted expansion of the paper.

**TABLE 1. SIZE OF SALMON AND NUMBER OF EGGS**

| Item | 2-year sea-life salmon | 3-year sea-life salmon | Previously-spawned salmon |
|---|---|---|---|
| Number of salmon | 503 | 15 | 16 |
| Weight (pounds) | 10.61 | 19.13 | 16.68 |
| Number of eggs | | | |
| Total | 8,848 ± 68 | 13,833 ± 483 | 12,313 ± 648 |
| Per pound of fish | 834 ± 5 | 723 ± 13 | 738 ± 34 |

## The Number of Eggs

*Variation with the size of salmon*—The influence of the size of the salmon upon the number of eggs is shown in Table 1, which gives a comparison of three sea-life classes. Although the number of 3-year sea-life and previously-spawned salmon is small, the averages of the numbers of eggs per individual are sufficiently reliable to indicate the wide difference in the total egg production of large and small fish. The data show also that the number of eggs per pound of fish is lower in the large salmon. The fact that large salmon usually have larger eggs than do small salmon may explain in part the smaller number of eggs per pound of fish in the 3-year sea-life and previously-spawned salmon.

*Total number of eggs per individual in the different groups of salmon*—Table 2 gives a comparison of the average number of eggs in

**TABLE 2. PRODUCTION OF EGGS BY 2-YEAR SEA-LIFE SALMON**

| Locality and type | Number of salmon | Average weight (pounds) | Average number of eggs: Total number | Average number of eggs: Number per pound of fish |
|---|---|---|---|---|
| Miramichi River | 163 | 9.40 | 7,678 ± 86 | 817 ± 8 |
| Coastal waters | | | | |
| Miramichi type | 210 | 10.68 | 8,905 ± 95 | 834 ± 10 |
| Chaleur Bay type | 130 | 11.97 | 10,223 ± 134 | 854 ± 12 |
| Total or average | 340 | 11.17 | 9,409 ± 78 | 842 ± 7 |
| Grand total or average | 503 | 10.61 | 8,848 ± 68 | 834 ± 5 |

the 2-year sea-life salmon of the coastal and river groups. There is a definite difference between the Miramichi River salmon and the coastal salmon of the Chaleur Bay type, while the Miramichi type occupies an intermediate position. The frequency-distribution curves further emphasize this difference. The coastal salmon of the Chaleur Bay type yielded 1.33 times as many eggs (10,223) as the Miramichi River salmon (7,678). McGregor (1923) found that the Sacramento River chinook salmon produced 1.72 times as many eggs (7,454) as the Klamath River chinook salmon (3,760). Apparently the total egg production of the Atlantic salmon is higher than that of the chinook salmon.

Comparisons of river varieties on the basis of the total number of eggs are misleading, since they do not take into account the size of the salmon. Unless salmon of similar weights and sea-life classes are compared, the results may be misinterpreted.

*Number of eggs per pound of fish*—Since the total number of eggs increases with the size of the salmon and since the weight of salmon of the same sea-life age varies in different rivers, the average number of eggs per pound of fish gives a more exact picture than the total number of eggs. When the average number of eggs per pound of fish is considered, the coastal salmon of the Chaleur Bay type yield only 1.05 times as many eggs (854) as the Miramichi River salmon (817) and there is little difference in the two frequency-distribution curves.

When the factor of size is eliminated by comparing the number of eggs per pound of fish for the same sea-life class, there still remains an appreciable, though small, difference between the Miramichi River salmon (817 eggs), and the coastal salmon of the Chaleur Bay type (854 eggs). The greater number of eggs per pound of fish in the coastal salmon of the Chaleur Bay type is not due to the larger size of the eggs in this group, since the production of larger eggs would tend to diminish rather than increase the number of eggs per pound of fish. In this instance the difference must be considered minimal, since some salmon of the Miramichi type may have been included in the Chaleur Bay group.

Observations on eggs from various salmon stocks indicate that the size of eggs of the same sea-life groups may vary in different rivers.

It is possible that the size and number of eggs may be hereditary characters.

## The Number of Pyloric Appendages

The first portion of the intestine, the pylorus, has an overlapping fringe of appendages that arise from its outer curvature. The appendages are slender, tapering, round tubes, averaging from 6 to 7 centimeters in length and 3 millimeters in width. Their structure is similar to but simpler than that of the intestine. Their mucosa is moulded into elaborate longitudinal folds, which give in a limited space considerable surface for absorption and secretion.

McGregor (1923) has suggested that the number of pyloric appendages affords a possible basis for the separation of river varieties of chinook salmon. He found that the average number of pyloric appendages in the salmon of Klamath River was 132.2, whereas the average for salmon of the Sacramento River was 176.4. He observed further that the frequency-distribution curves separated at 154 with little overlapping. The Atlantic salmon of the Gulf of St. Lawrence have a smaller average number (55.4) of pyloric appendages than has the chinook salmon, and the numbers range from 40 to 74 in contrast with 107 to 214 for the chinook salmon.

**TABLE 3. NUMBER OF PYLORIC APPENDAGES OF 2-YEAR SEA-LIFE SALMON**

| Locality and type | Males | | Females | | Total | |
|---|---|---|---|---|---|---|
| | Number of salmon | Number of pyloric appendages | Number of salmon | Number of pyloric appendages | Number of salmon | Number of pyloric appendages |
| Miramichi River | 48 | 56.98 ± 0.64 | 142 | 56.03 ± 0.33 | 190 | 56.25 ± 0.29 |
| Coastal waters | | | | | | |
| Miramichi type | 42 | 56.22 ± 0.60 | 192 | 54.63 ± 0.27 | 234 | 54.88 ± 0.25 |
| Chaleur Bay type | 22 | 54.73 ± 1.09 | 115 | 55.10 ± 0.35 | 137 | 54.98 ± 0.34 |
| Total or average | 64 | 55.59 ± 0.52 | 307 | 54.79 ± 0.22 | 371 | 54.92 ± 0.20 |
| Grand total or average | 112 | 56.23 ± 0.41 | 449 | 55.17 ± 0.18 | 561 | 55.38 ± 0.17 |

Table 3 gives the average number of pyloric appendages for the three groups of 2-year sea-life salmon. There is no difference between the coastal salmon of the Miramichi and Chaleur Bay types, but the Miramichi River salmon show a slightly higher number. The frequency-distribution curves for the three groups, except for minor irregularities and a slight shift to the right in the curve for the Miramichi River salmon, approximately coincide. The differences in the number of appendages in the various groups of fish are so slight that this character is of no statistical value in differentiating river varieties of Atlantic salmon.

Little difference is found between the two sexes. The average number of appendages in the males (56.23) is about one more than in the females (55.17). This difference appears in the data for both the coastal salmon and the Miramichi River salmon.

## Summary

1. The number of eggs and pyloric appendages in relation to river varieties of the Atlantic salmon are discussed.

2. The Atlantic salmon has a larger number of eggs that has the chinook salmon. Two-year sea-life salmon, weighing 10.61 pounds, produce an average yield of 8,848 eggs, or 834 per pound of fish.

3. Unless salmon of similar weight and of the same sea-life classes are compared, differences in the total egg production are misleading. The average number of eggs per pound of fish is a more reliable index for comparison.

4. A definite, though slight, difference in the number of eggs per pound of fish was found between the salmon of the Miramichi River (817) and the coastal salmon of the Chaleur Bay type (854). This difference is not sufficiently great to warrant its use for identifying river varieties of salmon in the sea.

5. The Atlantic salmon has a smaller number of pyloric appendages (55.38), with a range from 40 to 74, than has the chinook salmon with a range of 107 to 214.

6. The difference in the number of pyloric appendages in the coastal salmon and the Miramichi River salmon is so slight that it has no practical value for differentiating river varieties.

## Literature Cited

McGregor, E. A.

1923. A possible separation of the river races of King salmon in ocean-caught fish by means of anatomical characteristics. California Fish and Game, 1923, Vol. 9, pp. 138-150.

# MIGRATION OF THE ATLANTIC SALMON (*SALMO SALAR*) IN THE GULF OF ST. LAWRENCE AS DETERMINED BY TAGGING EXPERIMENTS

DAVID L. BELDING

*Boston University School of Medicine, Boston, Massachusetts*

ABSTRACT

**The onshore migration of the Atlantic salmon in the Gulf of St. Lawrence in 1937 and 1938, as determined by the tagging experiments of the Quebec Salmon Commission, is described.**

**The salmon that were tagged at Cabot Strait were distributed to all parts of the Gulf of St. Lawrence except the eastern part of the north shore and the northern part of the west coast of Newfoundland. The salmon that were tagged at the eastern end of Belle Isle Strait were recaptured in the sections unoccupied by the Cabot Strait salmon. The separate regions of distribution, the difference in the time of run and the diverse characteristics of the two groups of salmon furnish convincing evidence that there are two distinct stocks of salmon entering the Gulf of St. Lawrence, one northerly through Bellė Isle Strait and the other southerly through Cabot Strait.**

**The extent of the distribution of the salmon from the tagging stations within the Gulf of St. Lawrence depends upon the location of the particular station. If the station is situated near the final river destination of the salmon, the distribution is local; and if the station is at some distance, coastal movements of various amplitudes are observed.**

## INTRODUCTION

A general investigation of the Atlantic salmon in the Gulf of St. Lawrence was begun in 1937 under the auspices of the Quebec Salmon Commission. Among other activities, the investigation included a study of the routes of migration and the movements of salmon during their onshore spawning journey. The program necessitated cooperative tagging experiments by the Dominion, Newfoundland and Quebec governments, which together regulate the fisheries of the Gulf of St. Lawrence. This report is a brief account of the results obtained in 1937 and 1938 at several tagging stations.

The Gulf of St. Lawrence (Figure 1) is bounded on the east by Newfoundland, on the south by Nova Scotia, on the west by New Brunswick and Quebec, and on the north by Quebec. It is connected with the Atlantic Ocean on the north by Belle Isle Strait, between Newfoundland and Labrador, and on the south by Cabot Strait, between Newfoundland and Cape Breton. It is noted for its extensive salmon fisheries and its famous salmon rivers.

## TAGGING STATIONS

Tagging stations, selected because of their geographical relation to the salmon fisheries, were established so as to encircle the entire Gulf of St. Lawrence. The stations considered in this paper were situated

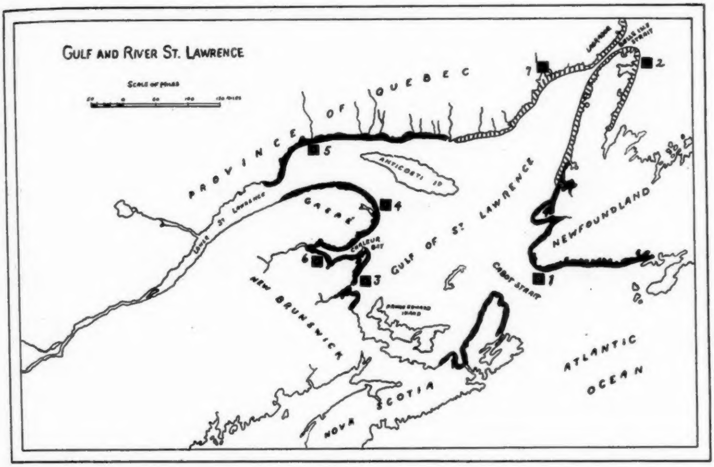


Figure 1.—Location of tagging stations and areas of distribution of salmon tagged at Port-aux-Basques, N. F., and St. Anthony, N. F. 1. Port-aux-Basques. 2. St. Anthony. 3. Miramichi Bay. 4. Petit Gaspé. 5. Seven Islands. 6. Black Point, Chaleur Bay. 7. St. Paul River. Areas of distribution of Port-aux-Basques salmon are indicated by solid black and those of St. Anthony salmon by cross-hatching.

at Port-aux-Basques, Newfoundland, on Cabot Strait; at St. Anthony, Newfoundland, east of Belle Isle Strait; at Miramichi Bay on the east coast of New Brunswick; at Seven Islands in the western section of the north shore of the Gulf of St. Lawrence; at Petit Gaspé at the end of the Gaspé Peninsula; at Black Point on the south shore of Chaleur Bay; and at St. Paul River in the eastern section of the north shore of the Gulf of St. Lawrence. At Port-aux-Basques and at Miramichi Bay the salmon used for tagging were taken in drift nets and at all the other locations in shore nets. For the first time salmon were tagged successfully after capture in gill nets such as are used in the drift-net fishery, about three-quarters of the catch being suitable for tagging.

## Percentages of Recapture

The number of salmon tagged and the percentages of recaptures are given in Table 1 in which the various tagging stations are grouped according to the range of distribution of the recaptured salmon. The marked difference in the percentages of recaptured salmon in 1937 and 1938 are interesting. The percentage of recaptures in 1938 was nearly twice that of 1937. Salmon spend a variable time in the coastal waters before ascending the rivers. In some years conditions favor

immediate entry into the rivers and in other years unsuitable conditions cause the salmon to remain longer in the coastal waters. Since most recaptured salmon are taken by the commercial fishermen, the higher percentage of recaptures in 1938 may have been due, in part, to factors that increased the length of time they were subjected to commercial fishing.

**TABLE 1. PERCENTAGE OF RECAPTURED ATLANTIC SALMON TAGGED IN 1937 AND 1938**

| Locality | 1937 Number of tagged salmon | 1937 Percentage recaptured | 1938 Number of tagged salmon | 1938 Percentage recaptured |
|---|---|---|---|---|
| **Areas of wide distribution** | | | | |
| Port-aux-Basques, N. F. | 599 | 13.3 | 494 | 26.3 |
| St. Anthony, N. F. | ...... | ...... | 175 | 22.3 |
| **Areas of restricted distribution** | | | | |
| Miramichi Bay, N. B. | 411 | 17.5 | 134 | 29.9 |
| Gaspé, P. Q. | 100 | 38.0 | 100 | 33.0 |
| Seven Islands, P. Q. | 80 | 8.8 | 38 | 21.1 |
| **Areas of local distribution** | | | | |
| Black Point, Chaleur Bay, N. B. | ...... | ...... | 72 | 37.5 |
| St. Paul River, P. Q. | 150 | 28.7 | ...... | ...... |

## Tagging Areas Showing Wide Distribution

The salmon at the two tagging stations at Port-aux-Basques, N. F., and St. Anthony, N. F., which are situated at the south and north entrances of the Gulf of St. Lawrence, for the most part moved westward and northward. These salmon probably were passing from the ocean into the Gulf of St. Lawrence; but since their oceanic source is unknown, it can be definitely stated only that they were present in the vicinity of the tagging stations. The distribution of the recaptured salmon (Figure 1) indicates that there are two stocks of salmon. One moves from Cabot Strait to all of the shores of the Gulf of St. Lawrence except the eastern section of the north shore. The other stock passes through Belle Isle Strait to the northeastern section of the Gulf of St. Lawrence.

*Port-aux-Basques*—The salmon at Port-aux-Basques on Cabot Strait were tagged at the drift-net fishery, which is conducted from 2 to 9 miles off shore directly south of Port-aux-Basques. The salmon tagged in 1937 and 1938 at this station were recaptured in the same coastal areas. In 1938, a relatively greater number of salmon was recaptured on the north shore, and a lower percentage on the west shore of the Gulf of St. Lawrence, than in 1937. Of the recaptured salmon 40 per cent was taken in Newfoundland, and 60 per cent in Canada. The distribution (Figure 1) was widespread. The tagged salmon were recaptured in all parts of the Gulf of St. Lawrence except in that section of the north shore east of Natashquan. The percentage distribution corresponded in general to the intensity of the commercial

fishing, except for an abnormally high percentage of recaptures in St. George Bay on the west coast of Newfoundland.

*St. Anthony*—The distribution (Figure 1) of the salmon tagged at St. Anthony in 1938 covered four areas: (1) the east coast of Newfoundland (few salmon), (2) the east coast of Labrador, (3) the north shore of the Gulf of St. Lawrence as far west as Natashquan, and (4) the west coast of Newfoundland as far south as Bay of Islands. Except for a slight overlapping on the west coast of Newfoundland, the distribution areas of the salmon from Port-aux-Basques and from St. Anthony were sharply separated.

*Time of Run*—There is considerable difference in the time of the salmon run at Port-aux-Basques in Cabot Strait and at St. Anthony near Belle Isle Strait. The peak of the run at Port-aux-Basques is about June 1, while that at St. Anthony is about June 21. The differences in the time of run and in the characteristics of the salmon indicate that the salmon of the two localities are of different oceanic sources.

The times of the salmon run in the respective areas of distribution from these tagging stations differ. In the section of the north shore of the Gulf of St. Lawrence east of Natashquan during the five-year period from 1931 to 1935 the peak of the commercial catch was progressively later from Belle Isle Strait to Natashquan, ranging from June 26 at Blanc Sablon to July 14 at the Washicoutai Archipeligo, just east of Natashquan. This westward wave corresponds to the westward movement of the St. Anthony salmon. On the coast just west of Natashquan, the most easterly point on the north shore of the Gulf of St. Lawrence where Port-aux-Basques salmon were captured, the peak of the commercial catch was earlier, about June 26.

In each instance the differences in the time of the run correspond approximately to the time necessary for the salmon to travel the intermediate distances from either St. Anthony or from Port-aux-Basques. The separate regions of distribution of the tagged salmon from these two stations, the differences in the time of the run of the salmon in the localities where the tagged salmon were recaptured, and the different characteristics of the two groups of salmon furnish convincing evidence that there are two distinct stocks of salmon entering the Gulf of St. Lawrence.

*Rate of travel*—The average distance travelled by the Port-aux-Basques salmon captured in Newfoundland was 113 miles and in Canada, 257 miles. The interval between tagging and recapture was fourteen days for Newfoundland and twenty-seven days for Canada. The average rate of travel was 9.6 miles per day for salmon recaptured in Newfoundland and 12.4 for those recaptured in Canada. The fastest salmon moved at a rate of 36 miles per day.

## Tagging Areas Showing Restricted Distribution

The three stations which show restricted distribution of salmon are:

(1) Miramichi Bay on the east coast of New Brunswick, (2) Petit Gaspé at the end of the Gaspé Peninsula, and (3) Seven Islands on the western section of the north shore of the Gulf of St. Lawrence.

*Miramichi Bay*—The Miramichi drift-net fishing area is situated on the east coast of New Brunswick in the vicinity of Miramichi Bay. Fishing is conducted for the most part in an irregularly contoured coastal area of about 400 square miles within a depth of 20 fathoms. During June and July large numbers of salmon congregate here, some staying but a short time and others remaining for months before seeking the rivers.

The distribution of the recaptured salmon in 1937 and 1938, other than local recaptures, was limited to two areas: the Miramichi River and the eastern coast of New Brunswick, and Chaleur Bay. The range, although fairly wide, was essentially local, extending from Kedgebougouac Beach, New Brunswick, to Gascons, Province of Quebec. The distribution of the recaptured salmon corresponded closely to the intensity of commercial fishing.

The distributions of recaptured salmon were similar in 1937 and 1938. Approximately one-half of the tagged salmon went to Chaleur Bay and one-half to the Miramichi River and the east coast of New Brunswick. It is interesting to note that a statistical analysis of the characteristics of these salmon in 1930 and 1931 gave the same proportion (52 per cent) of salmon bound for Chaleur Bay as is indicated by the tagging experiments in 1937 and 1938. The possibility that there was a free interchange of salmon between the Miramichi drift-net fishing area and Chaleur Bay was eliminated by the results of tagging experiments in Chaleur Bay. No salmon tagged in Chaleur Bay was taken outside that body of water.

*Gaspé*—The salmon tagged at Petit Gaspé on the inside of Grande Grève in 1937 and 1938 showed movements along the shore and a local distribution in Gaspé Bay. The major coastal movement was westward along the south side of the Gaspé Peninsula toward Chaleur Bay. A smaller number (one-third) moved northwesterly along the north side of the Gaspé Peninsula as far as Father's Point. Such coastwise movements are characteristic of salmon on reaching the shore, and in most instances there is a predominating movement in one direction.

*Seven Islands*—A group of small rocky islands, known as Seven Islands, lies at the entrance of Seven Islands Bay midway between Anticosti Island and Pointe des Monts. These islands are situated near the mouth of the Moisie River, one of the largest and most famous of the Quebec salmon rivers. The outermost of these islands, Carrousel Island, was selected as a tagging station because of its relation to the Mingan Channel and the main thoroughfare of the St. Lawrence River, and because salmon appear earliest in the season on the north shore of the Gulf of St. Lawrence at this locality.

In both years the salmon showed the same widespread dispersal along shore to the east and west of the point of tagging and to the south as far as Chaleur Bay. The dispersal to the east and west of Seven Islands is consistent with the usual movements of salmon, but the return journey of the salmon passing south to Chaleur Bay over a route previously travelled is inexplicable.

### Tagging Areas Showing Local Distribution of Salmon

The movements of salmon from the tagging stations in Chaleur Bay and at St. Paul River are local in character and indicate that the salmon have arrived near their river destination. In many instances there is a prevailing trend toward the rivers, but not infrequently the movements of the salmon appear aimless. The percentage of recaptures in these local areas as a rule is higher than in the areas of widespread distribution.

*Chaleur Bay*—In 1938 salmon were tagged at Black Point between Bathurst and Campbellton on the south side of Chaleur Bay. This station is situated about two-thirds of the distance from the outlet to the head of Chaleur Bay. The majority of the salmon moved westward along the shore toward the head waters of Chaleur Bay, where the large Restigouche River enters. The minority passed eastward to the Bathurst shores. No salmon were recaptured on the north side or outside the boundaries of Chaleur Bay. It is probable that salmon once having entered an elongated bay tend to remain within its confines.

*St. Paul River*—Tagging at St. Paul River on the eastern section of the north shore of the Gulf of St. Lawrence was conducted in an estuary some 10 or 12 miles in length. Two-thirds of the salmon showed to and fro movements, being taken within the estuary above and below the point of tagging. One-third left the estuary and were taken on the nearby outer coast. The tagging in this locality demonstrated that the movements of salmon within an estuary are erratic and that salmon taken in the estuary of a river do not necessarily enter that river for the purpose of spawning, but at times leave for other rivers.

# AN AERATING DEVICE FOR USE IN THE TRANSPORTATION OF FISH

A. E. BURGHDUFF
*California Division of Fish and Game*
*San Francisco, California*

The desirability of having water aerated automatically during the transportation of fish from hatcheries to the locality of planting has forced the development of many types of aerating apparatus, most of which, because of their cost or generally bulky characteristics, were applicable only to heavy types of planting equipment. We have now, by assembling commercially available equipment, built up a light type of aerator that is capable of aerating up to twenty-five cans of fish successfully and which can be installed complete for approximately fifteen dollars. It is the purpose of this paper to describe this new aerator.

This assembly consists first of a small-diaphragm air compressor operated directly by an ordinary automobile generator, used as a motor. No alterations are necessary in the wiring or methods of electrical connection; the generator is simply installed and used as a motor. This motor operates from the car battery; it consumes little current, and when the car is in use the load is carried by the generator rather than by the battery.

A rubber tube connects the compressor outlet with a manifold distributor mounted alongside the loading space or across the back of the cab. From this manifold, which is a 36-inch piece of ½-inch brass pipe, rubber lead tubes of the proper length reach all cans of fish. Attached to the end of each tube is an Aloxite carborundum tip or "releaser" which breaks the air into minute bubbles and provides much better aeration than was possible from the older types of releasers. At the end of the manifold is provided a petcock to serve as a by-pass for excess air. It has been determined that a pressure valve does not work satisfactorily at the low pressure used with this equipment. Each tube leading from the manifold is provided with a ring clamp which provides individual control of the air reaching each can. When the air is flowing to all cans at the same rate the by-pass petcock is opened to adjust the general rate of flow. Since it has been determined that fish consume about twice as much oxygen during the first hour in the cans as they require subsequently, a part of the air will need to be released through the by-pass after the first forty-five minutes or one hour.

As cans of fish are removed from the truck for planting, it is necessary to control the air so that the remaining cans will receive the proper amounts. This control can be accomplished by closing the ring clamps on the tubes leading to the cans that are removed and

by adjusting the petcock on the by-pass to permit the additional excess air to be released. A more simple method, and one requiring less adjustment, is to refill the first can emptied and, as additional cans are removed, to place the unused releasers in this can. This method of operation seldom renders necessary the readjustment of the ring clamps and makes possible all essential adjustments with the by-pass petcock.

A 12-inch side board is placed on the trucks to prevent direct wind currents from coming in contact with the cans and all cans are covered with four layers of 10-ounce burlap, which is kept wet. This combination reduces greatly the ice requirements—an excellent feature—for the sudden drop in temperatures that occurs with the introduction of ice is detrimental and should be avoided whenever practicable. With this equipment in use there is no reason for haste in planting; the men can leave the truck for any reasonable period of time with assurance that the fish will remain in good condition.

With the old system of hand aeration, the oxygen content of the water varied, and as a result the fish went through periods of distress. With each change the fish became gradually weaker and often reached their destination in a very poor condition.

With the oxygen content held constant at near saturation, the destination will be reached with fish in good condition and 30 per cent more fish can be carried in each can. Undoubtedly, an increased percentage of survival can be expected with the use of the new aerator. Proper aeration is particularly important in California, as our distances are so great. The assembly also has the advantage of being simple, inexpensive and as nearly "fool-proof" as any mechanical assembly could be. Improvements and refinements unquestionably will be made in this equipment, but as developed at present it provides a great improvement over our earlier methods of aeration.

---

## Discussion

Dr. R. P. Hunter: May I ask for further information about the type of compressor that is used?

Mr. Burghduff: The development of a diaphragm type of compressor is the only thing that made possible a unit of this kind. With a reciprocating type of compressor, much more power is required. As a matter of fact the little generator which we use as a motor develops only about one sixteenth of a horsepower. The same power applied to a reciprocating type of compressor, would not deliver sufficient air to aerate the twelve or fourteen cans of fish carried by the average truck. When this little motor is connected to a diaphragm air compressor which Sears, Roebuck and Co. sell at $3.35 each, we can aerate twenty-five to fifty cans of fish, depending upon the speed of the motor. These reconditioned motors we are using, taken from all types of automobiles, vary greatly in speed, but the faster ones will provide enough air to aerate forty to fifty 10-gallon cans of fish.

I might mention one other thing in connection with these tests. For a number of years we had had a considerable amount of trouble with the death after release among fish planted from different types of equipment. Dr. Paul Shaw, our chem-

ist, finally found the cause to be a metallic poison which did not affect the fish during transportation, in fact did not affect them until a number of hours after they were released in the streams. From careful observations we found that the loss would be sometimes as high as 40 to 50 per cent among fish that apparently went into the streams or lakes in splendid condition. The metallic poisoning originated in our water circulating tanks, which carry 500 gallons of water. Part of the piping in these tanks was made of galvanized iron. You cannot have the least bit of galvanized iron in any water in which you are carrying fish, without courting disaster. When we were developing this aerating equipment we purchased small carborundum blocks with a cadmium tube already in them. We found in our tests that the fish commenced to die in from twelve to sixteen hours after they were placed back in troughs or tanks. We eliminated this little piece of cadmium pipe and put in a piece of brass or rubber tubing instead, and the fish no longer were affected. If, therefore, you want to avoid disaster, do not use galvanized iron or cadmium, or anything other than plain brass or rubber tubing.

Mr. Glen Leach: Is it Mr. Burghduff's opinion that the nature of the water itself may have something to do with the condition resulting from the use of galvanized piping?

Mr. Burghduff: The quantity of zinc necessary to affect fish is so small that you get it under almost any conditions.

Mr. Leach: In the Bureau of Fisheries we use galvanized pipe almost exclusively for our water supply. We use it in our fish-distribution cars and trucks, and we have never had any adverse results.

Mr. Burghduff: To what extent did you check the results after the fish were planted?

Mr. Leach: We use various approved systems for supplying oxygen to the fish—oxygen tanks, air under pressure, water circulation. About two months ago we sent 80,000 3-inch brook trout a distance of about 400 miles in one of our large, specially equipped fish-distribution trucks, in which we have a water circulating system, fitted with galvanized pipes. The fish were landed without any appreciable loss.

Mr. Burghduff: In what condition were they twelve hours later?

Mr. Leach: We have every reason to believe they were in good condition. We transferred them to the hatchery and we had no complaints. They were not released in the stream; we have a sub-station in the vicinity where we hold the fish and rear them. We have had no complaints up to the present time, and the delivery was made two months ago. If the pipe is cleaned properly we never have any trouble. We have had trouble in transporting trout in galvanized iron cans. The use of a copper solution will overcome much of the difficulty occasioned through the use of galvanized iron cans.

Mr. Burghduff: I will agree with that. We find that copper will offset largely the effect of the galvanizing. In fact if you hang copper screens or copper valves or scrap copper of some kind into the tank, it will neutralize the effect of the zinc.

Dr. Paul Shaw: I believe it is quite possible that galvanized metal which contains a certain amount of copper would obviate the difficulties that have been described. A strip of copper in with the galvanized iron neutralizes the toxicity. I may add that there seems to be also a tendency on the part of the fish to develop resistance to zinc poisoning.

Mr. Leach: This question of the distribution of trout is a very important one, and one in which a great many of the states are interested. The success of our work depends upon our devising means of carrying it out successfully. If you

can see that fish are in good condition twelve to forty-eight hours after they have been released, you know you are handling the fish properly. The Bureau of Fisheries made some experiments in the use of water circulation, and also in the use of air. We use air probably on a larger scale than we do water circulation, because our fish distributing cars are equipped with air compressors. The air is put under pressure of 80 to 100 pounds, and is cut down to 3 pounds with reducing valves when it is released in the cans with the fish. We are using air on our fish distribution trucks. Lately we have experimented with the booster pumps that are used on some of the larger trucks—by building up an air pressure in a tank to 25 or 30 pounds and then reducing it to 2 or 3 pounds. Up to the present time, however, we have been able to carry more fish by circulating water; with large fish distribution trucks we can carry 80,000 to 100,000 3-inch trout in one truck. We carry about a hundred and twenty of the 5-gallon distribution buckets in a truck equipped with air.

Mr. Burghduff: I am interested very much in Mr. Leach's remarks. At the present time we are also putting air equipment on our water-circulating tanks. We have found that in handling the larger fish where the tank is loaded heavily it is necessary to circulate a large amount of water in order to put the proper amount of oxygen into the water. Although the agitation of the water does not affect the larger fish, if you are carrying smaller fish for any length of time they are harmed by the movement of the water; the rainbow or steelhead trout fight the current all the time. It is not disastrous to eastern brook trout or Loch Leven trout, but with the rainbow, the steelhead or the black-spotted native trout, this constant agitation of the water is very trying. Therefore, we are putting air equipment on with our water circulation system so that we do not have to circulate the water too rapidly and cause violent agitation at all times. At the present time, we believe that the ultimate solution of aeration is going to be a combination of air and water, that is, putting the air directly into the water for aeration and circulating the water without making an extreme agitation in the tank.

Mr. Leach: So far as agitation of the water is concerned, it enters into our tanks at a pressure of 30 to 40 pounds. We have a small ½-inch pipe, surrounded with a 1-inch pipe, that goes down almost to the bottom of the tank. This larger pipe, with the water going down through it, carries a lot of air. That arrangement does away with the boiling action or agitation of which you speak.

# APPENDICES

# AMERICAN FISHERIES SOCIETY
## Organized 1870

---

### Certificate of Incorporation

---

We, the undersigned, persons of full age and citizenship of the United States, and a majority being citizens of the District of Columbia, pursuant to and in conformity with sections 599 to 603, inclusive, of the Code of Law for the District of Columbia, enacted March 3, 1901, as amended by the acts approved January 31 and June 30, 1902, hereby associate ourselves together as a society or body corporate and certifying in writing:

1. That the name of the Society is the American Fisheries Society.

2. That the term for which it is organized is nine hundred and ninety-nine years.

3. That its particular business and objects are to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interest of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish; with power:

(a) To acquire, hold and convey real estate and other property, and to establish general and special funds.

(b) To hold meetings.

(c) To publish and distribute documents.

(d) To conduct lectures.

(e) To conduct, endow, or assist investigation in any department of fishery and fish-culture science.

(f) To acquire and maintain a library.

(g) And, in general, to transact any business pertinent to a learned society.

4. That the affairs, funds and property of the corporation shall be in general charge of a council, consisting of the officers and the executive committee, the number of whose members for the first year shall be seventeen, all of whom shall be chosen from among the members of the Society.

Witness our hands and seals this 16th day of December, 1910.

| | |
|---|---|
| Seymour Bower | (Seal) |
| Theodore Gill | (Seal) |
| William E. Meehan | (Seal) |
| Theodore S. Palmer | (Seal) |
| Bertrand H. Roberts | (Seal) |
| Hugh M. Smith | (Seal) |
| Richard Sylvester | (Seal) |

Recorded April 16, 1911.

# CONSTITUTION AND BY-LAWS

OF THE

# AMERICAN FISHERIES SOCIETY

(As Amended June 27, 1939)

## ARTICLE I

### Name and Object

The name of this Society shall be American Fisheries Society.

The objects of this Society shall be to promote the cause of fish culture and its allied interests; to gather and diffuse information on all questions pertaining to fish culture, fish, and fisheries; and to unite and encourage those interested in fish culture, and fisheries problems.

## ARTICLE II

### Membership

The membership of this Society shall be classified as follows: Active, Club, Libraries, State, Patron, Honorary, and Corresponding.

*Active Members.*—Any person may upon a two-thirds vote of the members present at any regular annual meeting and upon the payment of one year's dues become an active member of this Society. The annual dues of active members shall be three ($3.00) dollars per year, payable in advance. Any active member may upon payment of fifty ($50.00) dollars become exempt from the payment of annual dues though retaining the privileges of active membership for the duration of his life.

*Club Members.*—Any sporting or fishing club or society, or any firm or corporation, upon a two-thirds vote of the members present at any regular meeting and upon the payment of one year's dues, may become a club member of this Society. The annual dues of club members shall be five ($5.00) dollars per year.

*Libraries.*—Libraries may be admitted to membership upon a two-thirds vote of the members present at any regular meeting and the payment of one year's dues. The annual dues for libraries shall be two ($2.00) dollars per year.

*State Memberships.*—Any state, provincial or federal department of the United States, Canada or Mexico may become a state member of this Society upon a two-thirds vote of the members present at any regular meeting and the payment of one year's dues. The annual dues for State memberships shall be twenty ($20.00) dollars per year.

*Patrons.*—Any person, society, club, firm or corporation, on approval of the Executive Committee and the payment of fifty ($50.00) dollars or more, may become a patron, and shall be listed in all the published membership lists of the Society.

*Honorary and Corresponding Members.*—Any person may be made an honorary or corresponding member of this Society upon a two-thirds vote of the members present at any regular annual meeting of the Society. The President of the United States, the President of Mexico, the Governors of the several states, and the Secretary of the Interior of the United States, the Governor-General of Canada,

the Lieutenant-Governors of the several Canadian provinces, and the Dominion Minister in Charge of Game and Fisheries shall be honorary members of this Society while occupying their respective official positions.

*Election of Members between Annual Meetings.*—The President, Secretary and Treasurer of the Society are hereby authorized to act upon all applications for memberships received while the Society is not in session.

*Rights and Duties of Members.*—Active members in good standing only shall have the right to vote at regular or special meetings of the Society. Any member is held to be in good standing whose dues are not more than one year past due. In case of non-payment of dues for one year, proper notice shall be given the member by the Treasurer in writing, and if such member remains delinquent one month from the date of such notice, his name shall be dropped from the roll of the Society. Such delinquent member, having been dropped for non-payment of dues, shall be ineligible for election as a new member for a period of one year, except upon payment of arrears and current dues. Each member of the Society in good standing, except honorary members, shall receive one copy of the annual volume of Transactions.

*Quorum.*—Twenty voting members shall constitute a quorum for the transaction of business at annual or other meetings of the Society.

## ARTICLE III

### Funds

*Current Fund.*—All moneys received from the payment of dues of active members, club members, libraries, life members, state members, sale of Transactions, contributions thereto, and from any miscellaneous sources, shall be credited to the Current Fund of the Society and shall be paid out only on vouchers regularly approved by the President and Secretary.

*Permanent Fund.*—The President, Secretary and Treasurer shall be the Trustees of the Permanent Fund. All moneys received from patrons, bequests and contributions thereto shall be credited to the Permanent Fund of the Society. Such fund shall be invested by the Treasurer in such manner as may be approved by the trustees of such fund. The members of the Society shall, at each annual meeting, determine the disposition of interest accruing from such investment.

## ARTICLE IV

### Officers

The officers of this Society shall be a president, a first vice-president, and a second vice-president, all of whom shall be elected for the term of one year and shall be ineligible for reelection to the same office until a year after the expiration of their terms; a secretary, a treasurer, a librarian, and five vice-presidents, one to be in charge of each of the following divisions or sections:

1. Fish Culture.
2. Commercial Fishing.
3. Aquatic Biology and Physics.
4. Angling.
5. Protection and Legislation.

The officers specified above, and the president of the previous year, shall form

an Executive Committee* with authority to decide the policies of the Society and to transact such business of the Society as may be found necessary. The Executive Committee is authorized to fill from the membership any vacancies that may occur in any offices between meetings. A majority of the Executive Committee shall constitute a quorum.

Only members in good standing who are in attendance or have been in attendance at one of the two immediately preceding meetings shall be eligible for election to the offices listed above and for appointment to any committee, except the members of the Committee on Common and Scientific Names of Fishes.

The officers shall be elected by a majority vote at a regular meeting, a quorum being present.

No officer of this Society shall receive any salary or compensation for his services and no allowances shall be made for clerical services except by vote of the Society at regular annual meetings.

*Duties of Officers.*—The President shall preside at the regular and all special meetings of the Society and shall be ex-officio chairman of the Executive Committee.

The first Vice-President shall act in the place of the President in case of absence or inability of the latter to serve.

The Secretary shall keep the records of the Society, conduct its correspondence, promote its membership, and arrange for regular and special meetings. The Secretary shall also attend to the publication and distribution of the annual issuance of Transactions.

The Treasurer shall receive and collect all dues and other income of the Society, shall have the custody of its funds and pay all claims which have been duly approved. The Treasurer shall furnish a bond in the sum of seven thousand, five hundred ($7,500) dollars to be approved by the Executive Committee and to be paid for by the Society. The offices of Secretary and Treasurer may be occupied by the same person.

The Librarian shall have the custody of the library of the Society, including its permanent records and printed Transactions, and shall have charge of the sale of surplus copies of such Transactions.

The Vice-President of each division shall become conversant with the subject of his division and present a report on it at the regular meeting, placing emphasis upon developments during the past year.

Committee members shall cooperate in performing the functions of their appointments and render reports as directed by the President.

## ARTICLE V

### Standing Committees

The standing committees shall be Executive; Foreign Relations; Common and Scientific Names of Fishes; and Publications. The Committee on Publications shall be appointed by the President. The Executive Committee shall be selected as provided for by Article IV.

The Committee on Foreign Relations shall be composed of seven members selected by the nominating committee for election, and its duties shall be to exchange ideas pertaining to the various phases of fisheries administration, biology, including fish culture, with foreign fisheries biologists, conservation and fisheries administration officials, fish-culturists or aquicultural societies. A report based on such exchange should be presented at each regular meeting.

The Committee on Common and Scientific Names of Fishes shall be composed of seven members selected by the nominating committee for election. Its duties shall be to establish and maintain in the files of the Librarian of this Society a

*The Council was discontinued and the Executive Committee enlarged by Amendment to By-Laws, September 11, 1935.

correct check list of the species of fishes occurring in the waters of the United States and Canada. This list should contain both scientific and common names.

The Committee on Publications shall be composed of five members, and its duties shall be to select and edit manuscripts submitted for publication. Papers shall be submitted ready for publication within thirty days after the close of the regular meeting. Such papers, together with the minutes of the regular and special meetings and the reports of the various divisions and committees, shall be published in an annual volume which shall be numbered in series with previous volumes and entitled: TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY.

## ARTICLE VI

### MEETINGS

The regular meeting of the Society shall be held once a year, the time and place to be decided upon at the preceding meeting, or, in default of such action, by the Executive Committee. Special meetings shall be called by the President upon approval of a majority of the Executive Committee.

## ARTICLE VII

### ORDER OF BUSINESS

1. Call to order by the President.
2. Roll call of members.
3. Application for memberships.
4. Reports of officers:
   a. President
   b. Secretary
   c. Treasurer
   d. Vice-Presidents of Divisions
   e. Standing Committees
   f. Special Committees
5. Committees appointed by the President:
   a. Committee of five on nomination of officers and standing committees for the ensuing year.
   b. Committee of five on time and place of next meeting.
   c. Committee of five on resolutions.
   d. Auditing committee of three.
   e. Committee of three on program.
   f. Committee of three on publicity.
   g. Committee of five on publications.*
6. Reading of papers and discussions of same. In the reading of papers preference shall be given to the members present.
7. Miscellaneous business.
8. Adjournment.

## ARTICLE VIII

### CHANGING BY-LAWS

The By-Laws of the Society may be amended, altered or repealed by a two-thirds vote of the members present at any regular meeting, provided at least twenty-five members are present at said regular meeting.

*A resolution adopted August 24, 1937 established a staggered committee of five and provided that each succeeding President shall appoint one new member for a term of five years and designate the Chairman of the Committee.

# AMERICAN FISHERIES SOCIETY

## LIST OF MEMBERS

(Showing year of election to membership)

### HONORARY MEMBERS

The President of the United States.
The President of Mexico.
The Secretary of the Interior of the United States.
The Governors of the several States.
The Governor-General of Canada.
The Lieutenant-Governors of the several Canadian Provinces.
The Dominion Minister in Charge of Game and Fisheries.
'08 Antipa, Prof. Gregoire, Inspector-General of Fisheries, Bucharest, Roumania
'06 Besana, Giuseppe, Lombardy Fisheries Society, Via Rugabello 19, Milan, Italy
'09 Blue Ridge Rod and Gun Club, Harper's Ferry, W. Va.
'04 Denbigh, Lord, London, England.
'09 Nagel, Hon. Chas., St. Louis, Mo.
'08 Nordqvist, Dr. Oscar Fritjof, Superintendent of Fisheries, Lund, Sweden.

### PATRONS

'14 Alaska Packers Association, San Francisco, Calif.
'15 Allen, Henry F. (Agent Crown Mills), 210 California St., San Francisco, Calif.
'15 American Biscuit Co., 815 Battery St., San Francisco, Calif.
'15 American Can Co., Mills Building, San Francisco, Calif.
'15 Armour & Co., Battery and Union Sts., San Francisco, Calif.
'15 Armsby, J. K., Company, San Francisco, Calif.
'15 Atlas Gas Engine Co., Inc., Foot of 22nd Avenue, Oakland, Calif.
'15 Balfour, Guthrie & Co., 350 California St., San Francisco, Calif.
'15 Bank of California, N. A., California and Sansome Sts., San Francisco, Calif.
'15 Bloedel-Donovan Lumber Mills, Bellingham, Wash.
'15 California Barrel Co., 22d and Illinois Sts., San Francisco, Calif.
'15 California Door Co., 43 Main St., San Francisco, Calif.
'15 California Stevedore & Ballast Co., Inc., 210 California St., San Francisco, Calif.
'15 California Wire Cloth Company, San Francisco, Calif.
'15 Caswell, Geo. W., Co., Inc., 503-4 Folsom St., San Francisco, Calif.
'15 Coffin-Redington Co., 35-45 Second St., San Francisco, Calif.
'15 Columbia River Packers Association, Astoria, Ore.
'15 Crane Co., C. W. Weld, Mgr., 301 Brannon St., San Francisco, Calif.
'15 First National Bank of Bellingham, Bellingham, Wash.
'15 Fuller, W. P., & Co., 301 Mission St., San Francisco, Calif.
'15 Grays Harbor Commercial Co., Foot of 3d St., San Francisco, Calif.
'15 Jones-Thierbach Co., The, Battery and Merchant Sts., San Francisco, Calif.
'15 Knapp, The Fred H., Co., Arcade-Maryland Casualty Building, Baltimore, Md.
'15 Linen Thread Co., The, W. A. Barbour, Mgr., 443 Mission St., San Francisco, Calif.
'15 Morrison Mill Co., Inc., Bellingham, Wash.
'15 Morse Hardware Co., Inc., 1025 Elk St., Bellingham, Wash.
'15 Pacific Hardware & Steel Co., 7th and Townsend Sts., San Francisco, Calif.
'15 Pacific States Electric Co., 575 Mission St., San Francisco, Calif.
'15 Pope and Talbot, Foot of 3d St., San Francisco, Calif.

'15 Puget Sound Navigation Co., Seattle, Wash.
'15 Ray, W. S. Mfg. Co., Inc., 216 Market St., San Francisco, Calif.
'15 Schmidt Lithograph Co., 2d and Bryant Sts., San Francisco, Calif.
'15 Schwabacher-Frey Stationery Co., 609-11 Market St., San Francisco, Calif.
'15 Sherwin-Williams Co., The, 454 Second St., San Francisco, Calif.
'15 Ship Owners' and Merchants' Tug Boat Co., Foot of Green St., San Francisco, Calif.
'15 Smith Cannery Machine Co., 2423 South First Avenue, Seattle, Wash.
'15 Standard Gas Engine Co., Dennison and King Sts., Oakland, Calif.
'15 Standard Oil Co. of California, Standard Oil Building, San Francisco, Calif.
'15 U. S. Rubber Co. of California, James B. Brady, Gen. Mgr., 2nd and Folsom Sts., San Francisco, Calif.
'15 U. S. Steel Products Co., Rialto Building, San Francisco, Calif.
'15 Wells Fargo National Bank of San Francisco, Montgomery and Market Sts., San Francisco, Calif.
'15 Western Meat Co., 6th and Townsend Sts., San Francisco, Calif.
'15 White Bros., 5th and Brannon Sts., San Francisco, Calif.

## LIFE MEMBERS

'12 Barnes, Ernest, Fisheries Experiment Station, Wickford, R. I.
'00 Beeman, Henry W., New Preston, Conn.
'13 Belding, Dr. David L., 80 East Concord St., Boston, Mass.
'80 Belmont, Perry, 1618 New Hampshire Ave., Washington, D. C.
'97 Birge, Dr. E. A., University of Wisconsin, Madison, Wis.
'04 Buller, A. G., Pennsylvania Fish Commission, Corry, Pa.
'12 Buller, Nathan R., Pennsylvania Fish Commission, Harrisburg, Pa.
'26 Cary, Guy, 55 Wall St., New York, N. Y.
'04 Coker, Dr. Robert E., University of North Carolina, Chapel Hill, N. C.
'01 Dean, Herbert D., Northville, Mich.
'15 Folger, J. A., Howard and Spencer Sts., San Francisco, Calif.
'12 Fortmann, Henry F., 1007 Gough St., San Francisco, Calif.
'26 Goelet, Robert W., 18 East 47th St., New York, N. Y.
'22 Grammes, Charles W., Hamilton Park, Allentown, Pa.
'03 Gray, George M., Marine Biological Laboratory, Woods Hole, Mass.
'28 Hall, W. A., Co., Gardiner, Mont.
'10 Hopper, George L., Havre De Grace, Md.
'23 Kienbusch, C. O., 12 E. 74th St., New York, N. Y.
'22 Kulle, Karl C., Suffield, Conn.
'26 Lackland, Sam H., 69 So. Ann St., Mobile, Ala.
'23 Lloyd-Smith, Wilton, 63 Wall St., New York, N. Y.
'26 Low, Ethelbert I., 256 Broadway, New York, N. Y.
'15 Mailliard, Joseph, 1815 Vallejo St., San Francisco, Calif.
'99 Morton, W. P., 105 Sterling Ave., Providence, R. I.
'16 Nelson, Charles A. A., Lutsen, Minn.
'07 Newman, Edwin A., 4205 8th St., N. W., Washington, D. C.
'31 Nicholas, E. Mithoff, 20 S. 3d St., Columbus, Ohio.
'10 Osburn, Prof. Raymond C., Ohio State University, Columbus, Ohio.
'04 Palmer, Dr. Theodore S., 1939 Biltmore St., N. W., Washington, D. C.
'10 Radcliffe, Dr. Lewis, 5600 32nd St., N. W., Washington, D. C.
'05 Safford, W. H., 229 Wing St., S., Northville, Mich.
'00 Thompson, W. T., 121 N. Willson, Bozeman, Mont.
'13 Timson, William, Alaska Packers' Association, San Francisco, Calif.
'12 Townsend, Dr. Charles H., New York Aquarium, New York, N. Y.
'11 Valette, Luciano H., Echevarria F. C. S., Buenos Aires, Argentina, S. A.
'22 Walcott, Frederic C., Norfolk, Conn.
'98 Ward, Dr. Henry B., 1201 Nevada St., Urbana, Ill.
'97 Wood, Colburn C., Box 355, Plymouth, Mass.

## ACTIVE MEMBERS

'35 Adams, Harry E., U. S. Forest Service, Milwaukee, Wis.
'33 Adams, Milton P., 638 Sunset Lane, East Lansing, Mich.
'13 Adams, William C., Dept. of Conservation, Albany, N. Y.
'29 Ainsworth, A. L., Tuxedo Fisheries, Tuxedo Park, N. Y.
'33 Albert, W. E., Jr., Lansing, Iowa.
'38 Alderson, I. T., Von Hoffman Press, 101 S. 9th St., St. Louis, Mo.
'31 Aldrich, A. D., 2879 East Archer, Tulsa, Okla.
'34 Alexander, George J., Parliament Bldgs., Victoria, B. C., Canada.
'36 Allen, Edward W., Northern Life Tower, Seattle, Wash.
'29 Allen, William Ray, Dept. of Zoology, University of Kentucky, Lexington, Ky.
'32 Allen, Dr. William S., P. O. Box 7, Sherbrooke, P. Q., Canada.
'26 Alm, Dr. Gunnar, Commissioner of Freshwater Fisheries, Lantbruksstyrelsen, Stockholm, Sweden.
'33 Anderson, Albin, 376 E. Maryland St., St. Paul, Minn.
'08 Anderson, August J., Box 704, Marquette, Mich.
'39 Anderson, David, University Museums, Ann Arbor, Mich.
'24 Annin, Harry K., Spring Street, Caledonia, N. Y.
'14 Annin, Howard, Van Cortland Ave., Ossining, N. Y.
'37 Atkinson, Clinton E., Westminster Trust Bldg., New Westminster, B. C., Canada.
'29 Atkinson, C. J., Fisheries Dept., Ottawa, Ont., Canada.
'36 Atwood, Earl L., 213 S. Charter St., Madison, Wis.
'32 Baer, Harry D., U. S. Fisheries Station, Quinault, Wash.
'36 Bailey, Dr. Reeve M., Dept. of Zoology and Entomology, Iowa State College, Ames, Iowa.
'32 Bailliere, Lawrence, Stoutland, Mo.
'27 Baker, Clarence M., 2 South Carroll St., Madison, Wis.
'36 Baker, Dr. Clinton L., Southwestern, Memphis, Tenn.
'15 Balch, Howard K., 110 E. Seeboth St., Milwaukee, Wis.
'37 Ball, Robert, University Museums, Ann Arbor, Mich.
'23 Bangham, Dr. Ralph V., Wooster College, Wooster, Ohio.
'37 Banta, Emitt W., Saratoga, Wyo.
'05 Barbour, Prof. Thomas, Museum of Comparative Zoology, Cambridge, Mass.
'38 Barker, Elliott S., State Game and Fish Commission, Santa Fe, N. Mex.
'39 Barker, Roy E., Box 232, Magdalena, N. Mex.
'38 Barram, John, R. R. 6, Picton, P. Q., Canada.
'37 Bass, John F., Jr., 23 East Jackson Blvd., Chicago, Ill.
'37 Baumann, A. C., State Fish Farm No. 4, Russell's Point, Ohio.
'38 Bay, William I., Mt. Shasta, Calif.
'33 Beach, U. Sidney, Highland, Mich.
'37 Beckman, William, University Museums, Ann Arbor, Mich.
'37 Bedard, Avila, Deputy Minister of Lands and Forests, Quebec, P. Q., Canada.
'34 Bell, Edward B., 84 Foster St., Lowell, Mass.
'33 Bell, Frank T., Ephrata, Wash.
'37 Bennett, Dr. George W., Illinois Natural History Survey, Urbana, Ill.
'39 Berrian, William, Big Creek Hatchery, Davenport, Calif.
'37 Berube, Louis, School of Fisheries, Ste. Anne de la Pocatiere, P. Q., Canada.
'37 Bickelhaupt, F. R., Lakefield Farm, Burton, Ohio.
'36 Biddle, Spencer, R. F. D. 1, Vancouver, Wash.
'38 Bills, Preston, Mt. Shasta, Calif.
'27 Birdseye, Clarence, General Seafoods Corporation, Gloucester, Mass.
'34 Bishop, Dr. Sherman C., Dept. of Zoology, University of Rochester, Rochester, N. Y.
'38 Bjorn, Eugene E., Game and Fish Department, Cheyenne, Wyo.
'39 Blake, Thad M., U. S. Fisheries Station, Los Molinos, Calif.
'38 Bliss, Richard, Box 599, Mt. Shasta, Calif.
'32 Blosz, John, Lake Park, Ga.

'37 Blue, Junior Sauber, 1150 Woodside Drive, Flint, Mich.
'39 Bode, I. T., Conservation Commission, Jefferson City, Mo.
'36 Boesel, M. W., 415 S. Washington St., New Bremen, Ohio.
'38 Bohland, Richard, 1889 Robinson St., Muskegon, Mich.
'38 Bonham, Kelshaw, Box 254 F. E., College Station, Tex.
'38 Bonnot, Paul, Box 1075, Stanford University, Calif.
'37 Bosdish, Carl, State Fish Farm No. 9, R. D. 11, Defiance, Ohio.
'39 Bostwick, W. H., 950 Pacific Bldg., San Francisco, Calif.
'38 Bottinelli, M. J., 134 E. Market St., Kellogg, Ida.
'33 Bottvill, George, Bottvill's Fish Hatchery, R. 2, Palmyra, Wis.
'36 Bower, E. A., 986 Colfax Ave., Benton Harbor, Mich.
'00 Bower, Ward T., U. S. Bureau of Fisheries, Washington, D. C.
'34 Brass, J. L., Hastings, Mich.
'20 Breder, Dr. C. M., Jr., New York Aquarium, New York, N. Y.
'37 Brennan, Bert M., 1308 Smith Tower, Seattle, Wash.
'38 Bronson, Elliott P., State Office Bldg., Hartford, Conn.
'34 Brown, Dr. C. J. D., Institute for Fisheries Research, University Museums, Ann Arbor, Mich.
'30 Brown, James, Dept. of Conservation, Frankfort, Ky.
'34 Brown, Louis P., Insurance Bldg., Glens Falls, N. Y.
'32 Brown, Merrill W., Division of Fish and Game, 303 State Office Building, Sacramento, Calif.
'20 Buller, C. R., Pleasant Mount, Wayne County, Pa.
'38 Burghduff, A. E., Ferry Bldg., San Francisco, Calif.
'39 Burrows, Roger E., U. S. Fisheries Station, Quilcene, Wash.
'30 Butler, George Edward, Dauphin River Hatchery, Ridley P. O., via Gypsum ville, Man., Canada.
'36 Butler, Ray, Clear Lake, Iowa.
'27 Byers, A. F., 5606 Queen Mary Rd., Montreal, Que., Canada.
'27 Cable, Louella E., Charleston Museum, Charleston, S. C.
'36 Cahalane, Dr. Victor H., National Park Service, Washington, D. C.
'36 Cahn, Dr. A. R., Cleveland, Fla.
'39 Calhoun, Alexander J., Natural History Museum, Stanford University, Calif.
'35 Carbine, William F., Institute for Fisheries Research, Ann Arbor, Mich.
'39 Carl, Dr. George Clifford, Cowichan Lake Hatchery, Lake Cowichan, B. C., Canada.
'39 Carman, L. Q., U. S. Fisheries Station, Dexter, N. Mex.
'23 Catt, James, District Inspector of Hatcheries, Customs House, St. John, N. B., Canada.
'38 Chamberlain, Thomas Knight, Pisgah Forest, N. C.
'38 Chandler, C. W., Div. of Fish and Game, Bass Lake, Calif.
'38 Chapman, Wilbert McLeod, Washington State Fisheries Laboratory, University of Washington, Seattle, Wash.
'38 Cheyne, Harlan, State Fish Hatchery, Rt. No. 7, Spokane, Wash.
'29 Chute, Walter H., Director, John G. Shedd Aquarium, Grant Park, Chicago, Ill.
'38 Clanton, D. A., Box 470, San Bernardino, Calif.
'32 Clark, Arthur L., Dept. of Conservation, Jefferson City, Mo.
'37 Clark, Clarence T., 513 E. Columbia St., St. Marys, Ohio.
'33 Clark, G. H., Ferry Bldg., San Francisco, Calif.
'36 Clark, O. H., Jr., Institute for Fisheries Research, University Museums, Ann Arbor, Mich.
'21 Clemens, Dr. Wilbert A., Pacific Biological Station, Nanaimo, B. C., Canada.
'00 Cobb, Eben W., 1180 Delaware Ave., St. Paul, Minn.
'34 Cobb, Kenneth E., Windsor Locks, Conn.
'38 Conner, Joe D., P. O. Box 46, Morristown, Tenn.
'35 Conner, J. T., Box 357, Springfield, Tenn.
'28 Cook, A. B., Jr., Field Supt. of Hatcheries, Ionia, Mich.

'35 Cook, Blendon H., U. S. Fisheries Station, Bozeman, Mont.
'38 Cook, J. H., Bishop, Calif.
'17 Cook, Ward A., U. S. Bureau of Fisheries, Duluth, Minn.
'33 Cooper, Dr. Gerald P., Univ. of Maine, Orono, Me.
'33 Corcoran, John P., Pioneer Point Farm, Centreville, Md.
'38 Council for Scientific and Industrial Research, Officer in Charge, New Commonwealth Offices, 318 P. O. Place, Melbourne C. 1, Victoria, Australia.
'37 Cox, Harry B., U. S. Fisheries Station, Clackamas, Ore.
'13 Crandall, A. J., Ashaway Line & Twine Mfg. Co., Ashaway, R. I.
'33 Croker, Richard, State Fisheries Laboratory, Terminal Island, Calif.
'28 Crosby, Col. W. W., Box 685, Coronado, Calif.
'39 Crump, Lee, 106 S. Main St., Pittsford, N. Y.
'08 Culler, C. F., U. S. Bureau of Fisheries, La Crosse, Wis.
'36 Curran, H. Wesley, Dept. of Biology, Queen's University, Kingston, Ont., Canada.
'34 Curtis, Brian C., Div. of Fish and Game, Sacramento, Calif.
'36 Curtis, Harland K., R. F. D. 1A, Auburn, Me.
'34 Davis, George William, 377 Orange St., Albany, N. Y.
'39 Davis, Herbert C., Div. of Fish and Game, San Francisco, Calif.
'23 Davis, Dr. H. S., U. S. Bureau of Fisheries, Kearneysville, W. Va.
'38 Davis, W. B., Dept. Wild Game, College Station, Tex.
'39 Day, Albert M., 2437 North Quantico St., Arlington, Va.
'26 Day, Harry V., 510 Park Ave., New York, N. Y.
'33 Deason, Dr. H. J., U. S. Bureau of Fisheries, University Museums, Ann Arbor, Mich.
'27 DeBoer, Marston J., Dept. of Conservation, Lansing, Mich.
'25 De Cozen, Alfred, 1226 Broad St., Newark, N. J.
'28 De Forest, Byron, P. O. 971, Great Falls, Mont.
'37 Delisle, Henry A., U. S. Fisheries Station, Berlin, N. H.
'37 Dellinger, S. C., 217 Ozark, Fayetteville, Ark.
'24 Dence, Wilford A., New York State College of Forestry, Syracuse, N. Y.
'19 Denmead, Talbott, 2830 St. Paul St., Baltimore, Md.
'38 Dennig, L. S., 20 Brentmoor, St. Louis, Mo.
'33 Deuel, Charles R., State Fish Hatchery, Gloversville, N. Y.
'38 Dill, William A., Fresno State College, Fresno, Calif.
'99 Dinsmore, A. H., U. S. Bureau of Fisheries, St. Johnsbury, Vt.
'38 Dixon, Dr. R. K., 1104 Republic Bldg., Denver, Colo.
'32 Domogalla, Dr. Bernhard, 803 State St., Madison, Wis.
'34 Donaldson, Lauren R., Dept. of Fisheries, University of Washington, Seattle, Wash.
'36 Donaldson, Paul D., Box 1022, Station A., Grand Coulee, Wash.
'35 Doudoroff, Peter, Scripps Institute of Oceanography, LaJolla, Calif.
'36 Douglass, Edward J., Bureau of Fisheries, Washington, D. C.
'36 Duddy, Thomas, Cambridge, N. Y.
'28 Dunlop, Henry A., International Fisheries Com., University of Washington, Seattle, Wash.
'24 Earle, Swepson, Maryland University, College Park, Md.
'38 Eddy, Dr. Samuel, University of Minnesota, Minneapolis, Minn.
'39 Edwards, Frank A., 1737 67th Ave., Oakland, Calif.
'34 Elkins, Winston A., U. S. Forest Service, Milwaukee, Wis.
'34 Ellis, Dr. M. M., 101 Willis Ave., Columbia, Mo.
'33 Ellsworth, Robert E., Silver Creek Trout Station, East Tawas, Mich.
'39 Embody, Daniel R., Cornell University, Ithaca, N. Y.
'35 Erekson, Z. Y., Mantua, Utah.
'34 Erkkila, Leo, 180 Duboce Ave., San Francisco, Calif.
'32 Eschmeyer, Dr. R. William, T.V.A., Norris, Tenn.
'39 Esveldt, Geo. D., Box 255, Usk, Wash.
'04 Everman, J. W., Supervisor of Public Utilities, Dallas, Tex.

'35 Ewers, Dr. Lela A., Cottey College, Nevada, Mo.
'38 Faulkner, Luther W., High St., Chelmsford Center, Mass.
'28 Fearnow, Theodore C., Berkeley Springs, W. Va.
'32 Fellers, Dr. Carl R., Massachusetts State College, Amherst, Mass.
'38 Fellows, David A., 206 Paterson Bldg., Flint, Mich.
'30 Fentress, Eddie W., Manicao, Puerto Rico.
'32 Fiedler, R. H., U. S. Bureau of Fisheries, Washington, D. C.
'35 Fink, Carl, Deer Creek Lodge, Mineral, Calif.
'31 Fish, Dr. Frederic F., U. S. Fisheries Laboratory, 2725 Montlake Blvd. Seattle, Wash.
'37 Fisher, Russell V., Culver, Ind.
'33 Fisk, Harry T., Crown Point, N. Y.
'38 Fleming, F. A., Morrisonville, Ill.
'36 Flores, Francisco G., 2506 Shoreland Dr., Seattle, Wash.
'28 Foerster, Dr. R. Earle, Westminster Trust Bldg., New Westminster, B. C., Canada.
'04 Follett, Richard E., 2134 Dime Bank Bldg., Detroit, Mich.
'36 Fontaine, Pierre A., 6039 Palo Pinto, Dallas, Tex.
'36 Foresman, B. L., Alger, Mich.
'36 Forster, Robert, 25 Academy Rd., Albany, N. Y.
'35 Foster, C. R., R. 5, Box 615, South Tacoma, Wash.
'38 Foster, Charles R., Jr., U. S. Fisheries Station, Spearfish, S. D.
'10 Foster, Frederick J., 2725 Montlake Blvd., Seattle, Wash.
'38 Foster, Richard F., 5147 Latimer Pl., Seattle, Wash.
'24 Frantz, Horace G., Frantzhurst Rainbow Trout Co., Salida, Colo.
'22 Fraser, Dr. C. McLean, University of British Columbia, Vancouver, B. C., Canada.
'38 Fraser, Melville J., 253½ Northern Ave., Boston, Mass.
'37 Fremont, Charles, Dept. of Colonization, Mines and Fisheries, Quebec, Canada
'37 French, Hon. Charles A., 319 Fourth St., Ellwood City, Pa.
'38 Freundenberg, Walter, Steelville, Mo.
'18 Fridenberg, Robert, 22 West 56th St., New York City, N. Y.
'35 Fruchter, W., Fisheries Station, Santa Rosa, N. Mex.
'36 Fry, Dr. F. E. J., University of Toronto, Toronto, Canada.
'35 Fuqua, Charles L., U. S. Fisheries Station, Bozeman, Mont.
'28 Gage, Simon H., Stimson Hall, Ithaca, N. Y.
'24 Gale, R. G., State Fish Hatchery, French River, Minn.
'39 Galvin, Pat, R. F. D. 1, Bendon, Mich.
'38 Gambrell, Roy, Arizona State Game Dept., Phoenix, Ariz.
'18 Garnsey, Leigh, Box 653, Redlands, Calif.
'37 Gaver, L. W., Grangeville, Idaho.
'37 Gebhart, James W., 4926 Donald Ave., South Euclid, Ohio.
'38 Gentry, Reeves, Steamboat Springs, Col.
'30 Gibaut, F. M., Dept. of Colonization, Game and Fisheries, Quebec, Canada.
'26 Gibbs, George, Pennsylvania Station, New York, N. Y.
'37 Gilmore, Ralph J., Colorado College, Colorado Springs, Colo.
'39 Goellner, Karl E., University Museums, Ann Arbor, Mich.
'35 Goldie, Dr. William, 86 College St., Toronto, Canada.
'27 Gordon, Seth, Game Commission, Harrisburg, Pa.
'37 Gottschalk, John, 406 State Library Bldg., Indianapolis, Ind.
'28 Grammes, J. Frank, Grammes Brook Trout Hatchery, 1119 Linden St., Allentown, Pa.
'36 Graves, D. N., Arkansas Game and Fish Commission, Little Rock, Ark.
'36 Gray, Donald V., East Tawas, Mich.
'26 Greeley, Dr. John R., Conservation Dept., Albany, N. Y.
'37 Greenbank, John, University Museums, Ann Arbor, Mich.
'29 Greene, Dr. C. Willard, N. Y. State Conservation Dept., Albany, N. Y.
'34 Griffiths, Francis P., Oregon State Agricultural College, Corvallis, Ore.

'31 Grim, D. N., Glen Eyre, Pa.
'37 Guenthner, Jacob, State Fish Farm No. 7, Piqua, Ohio.
'37 Gutermuth, C. R., 406 State Library Bldg., Indianapolis, Ind.
'38 Gutsell, Dr. James S., U. S. Fisheries Experimental Sta., Kearneysville, W. Va.
'38 Hagan, William, Jr., U. S. Bur. of Fisheries, 2725 Montlake Blvd., Seattle, Wash.
'26 Halferty, G. P., 600 Coleman Bldg., Seattle, Wash.
'38 Hall, Cornet, Redbridge, Ont., Canada.
'36 Hansen, Donald F., 219 Natural History Bldg., Urbana, Ill.
'10 Hansen, Ferdinand, Romanoff Caviar Co., Grand Central Palace, 480 Lexington Ave., New York, N. Y.
'38 Hanson, Harry A., U. S. Bureau of Reclamation, Redding, Calif.
'25 Hanson, Henry, State Fish Hatchery, Lanesboro, Minn.
'28 Harkness, William J. K., Dept. of Biology, University of Toronto, Toronto, Canada.
'37 Harner, Ernest, State Fish Farm No. 4, Xenia, Ohio.
'17 Harriman, W. A., 59 Wall St., New York, N. Y.
'39 Hartman, C., R. R. 2, Sault Ste Marie, Ont., Canada.
'34 Haskell, David C., Gansevoort, N. Y.
'38 Hatch, A. B., School of Forestry, University of Idaho, Moscow, Ida.
'38 Hatton, S. Ross, Natural History Museum, Stanford University, Calif.
'33 Hawes, Harry B., Transportation Bldg., Washington, D. C.
'38 Hayes, Elgin W., R. R. No. 6, Pembroke, Ont., Canada.
'04 Hayford, Charles O., State Fish Hatchery, Hackettstown, N. J.
'35 Hazard, T. P., Peace Dale, R. I.
'28 Hazzard, Dr. A. S., Institute for Fisheries Research, University Museums, Ann Arbor, Mich.
'38 Heacox, Cecil, Box 195, Lowville, N. Y.
'36 Heatley, J. W., Jackson Post Office, Nova Scotia, Canada.
'08 Hemingway, E. D., P. O. Box 246, Philadelphia, Pa.
'33 Herndon, G. B., 724 Mulberry St., Jefferson City, Mo.
'32 Herrington, William C., 48 Linden St., Arlington, Mass.
'33 Hewitt, Edward R., 127 East 21st St., New York, N. Y.
'35 Hickey, LeRoy W., Route 1, Box 764, Astoria, Ore.
'32 Higgins, Elmer, U. S. Bureau of Fisheries, Washington, D. C.
'35 Higgs, A., Qualicum Beach, B. C., Canada.
'15 Hildebrand, Dr. Samuel F., U. S. Bureau of Fisheries, Washington, D. C.
'32 Hile, Dr. Ralph, U. S. Bureau of Fisheries, University Museums, Ann Arbor, Mich.
'38 Hill, B. J., Div. of Conservation, Columbus, Ohio.
'36 Hill, R. R., U. S. Forest Service, Federal Bldg., Milwaukee, Wis.
'38 Hills, A. P., Atlantic Biological Station, St. Andrews, N. B., Canada.
'33 Hills, Clifford, State Fish Hatchery, Wild Rose, Wis.
'38 Hinks, David, 328 Rutland St., Winnipeg, Man., Canada.
'08 Hinrichs, Henry, 628 E. Valnett Ave., Arcadia, Calif.
'39 Hinze, James A., Div. of Fish and Game, Brookdale Hatchery, Brookdale, Calif.
'38 Hixson, W. W., Hixson, Tenn.
'35 Hoffmaster, P. J., Director, Dept. of Conservation, Lansing, Mich.
'23 Hogan, Joseph R., State Fisheries, Lonoke, Ark.
'39 Hoglund, Melvin L., U. S. Bureau of Fisheries, Estacada, Ore.
'37 Holland, R. P., 515 Madison Ave., New York, N. Y.
'36 Holloway, Ancil D., U. S. Forest Service, Glen Bldg., Atlanta, Ga.
'38 Holmes, Harlan B., 2725 Montlake Blvd., Seattle, Wash.
'37 Homans, Ross Evans Spencer, Hubbards, Nova Scotia, Canada.
'20 Hoofnagle, G. W., U. S. Fishery Station, Leadville, Colo.
'33 Hosley, N. W., Harvard Forest, Petersham, Mass.
'35 Hosselkus, B. C., Creede, Colo.
'36 Howe, M. W., 1001 E. Delavan Ave., Buffalo, N. Y.
'31 Howley, Thomas, 2482 Tiebout Ave., New York, N. Y.

'23 Hubbard, Harry E., New Hampton, N. H.
'20 Hubbs, Dr. Carl L., University of Michigan, Ann Arbor, Mich.
'24 Huderle, John, State Fish Hatchery, Detroit Lakes, Minn.
'28 Hunter, Dr. George W., 3d, Shanklin Laboratory of Biology, Wesleyan University, Middletown, Conn.
'35 Hunter, Dr. R. P., State Board of Fisheries and Game, Hartford, Conn.
'13 Huntsman, Dr. A. G., University of Toronto, Toronto, Canada.
'38 Hussey, Ivo H., June Lake, Calif.
'35 Hutton, M. L., Ames, Iowa.
'38 Inland Fisheries Officer, P. O. Box 389, Pietermaritzburg, Natal, South Africa
'32 Jackson, Charles E., Acting Comr., U. S. Bureau of Fisheries, Washington, D. C.
'38 Jacocks, West, Chamber of Commerce, Columbia, S. C.
'32 James, C. C., Superintendent of State Fish Hatcheries, Summerville, Ga.
'28 James, Milton C., U. S. Bureau of Fisheries, Washington, D. C.
'39 Jarvis, J. Willard, State Game Commission, Philomath, Ore.
'37 Jennings, A. B., Cedaredge, Colo.
'17 Jensen, Harold, State Fish Hatchery, St. Peter, Minn.
'28 Jewell, Dr. Minna E., Dept. of Zoology, Thornton Junior College, Harvey, Ill.
'32 Jobes, Frank W., U. S. Bureau of Fisheries, University Museums, Ann Arbor, Mich.
'37 Johansen, John Maurity, 3444 35th Ave., West, Seattle, Wash.
'37 Johns, A. C., State Fish Farm No. 11, Chagrin Falls, Ohio.
'34 Johnson, Edwin L., 14 Forest Ave., St. Thomas, Ont., Canada.
'36 Johnson, Fred F., 5521 Colorado Ave., N. W., Washington, D. C.
'35 Johnson, Harlan E., Route 7, Spokane, Wash.
'35 Johnson, Harry, Verdi, Nev.
'33 Johnson, Jimmie, Game and Fish Dept., Santa Fe, N. Mex.
'25 Johnson, Maynard S., New Holland, N. C.
'35 Johnson, Rudolph E., Route 1, Arlington, Wash.
'39 Jones, Alden M., Norris, Tenn.
'36 Jones, Alton, Porters Lake Hunting and Fishing Club, Porters Lake, Pa (via Marshall Creek, P. O.)
'08 Jones, Thos. S., 1664 Spring Drive, Louisville, Ky.
'38 Jordan, Silas T., Mt. Shasta, Calif.
'18 Kauffman, R. M., "The Star," Washington, D. C.
'26 Kaul, William, Saint Marys, Pa.
'36 Keister, Arthur M., 825 West Lakeside St., Madison, Wis.
'28 Kemmerich, Alphonse, U. S. Bureau of Fisheries, Underwood, Wash.
'12 Kemmerich, Joseph, U. S. Bureau of Fisheries, Concrete, Wash.
'28 Kenell, Garfield, Hamilton Lake Lodge, Lake Pleasant, N. Y.
'37 King, Willis, Great Smoky Mountain National Park, Elkmont, Tenn.
'32 Kingsbury, Oliver R., South Otselic, N. Y.
'24 Kitson, James A., 20 Somerset St., Boston, Mass.
'37 Klak, George E., U. S. Fisheries Station, Kearneysville, W. Va.
'35 Knutsen, Arthur I., 3306 W. 70th St., Seattle, Wash.
'34 Koster, William J., University of New Mexico, Albuquerque, N. Mex.
'32 Kuehl, Eric O., U. S. Fisheries Station, Springville, Utah.
'38 Kuffel, Fred E., Mt. Shasta, Calif.
'37 Kuhne, Eugene R., Hart, Mich.
'33 Kunkel, Kenneth M., Fish and Game Div., State House, Indianapolis, Ind.
'36 Kuronuma, Katsuzo, 800 Hatagaya Laramachi, Shibuyaku, Tokyo, Japan.
'37 Lafond, Everett, 1820 Jackson St., Two Rivers, Wis.
'36 Lagler, Dr. Karl F., Zoology Dept., Univ. of Mich., Ann Arbor, Mich.
'25 Langlois, Dr. T. H., P. O. Box C, Put-in-Bay, Ohio.
'39 Lapp, Harvey E., 234 Martine Ave., White Plains, N. Y.
'29 Larsen, Henry A., Hayward, Wis.
'38 Larson, Keith D., Campbell, Minn.

'08 Lay, Charles E., Railroad St. Foot of Wayne St., Sandusky, Ohio.
'39 Leach, Charles, Rt. 7, Box 1478, Portland, Ore.
'19 LeCompte, E. Lee, 512 Munsey Bldg., Baltimore, Md.
'28 Leighton, F. W., Sonora, Calif.
'25 Leim, Dr. A. H., Atlantic Biological Station, St. Andrews, N. B., Canada.
'35 Leitritz, Earl, Fall Creek Hatchery, Copco, Calif.
'34 Lemay, Lionel, Université de Montreal, Rue St. Denis, Montreal, Canada.
'34 Leonard, Dr. Justin W., Institute for Fisheries Research, Box 5, Lewiston, Mich.
'38 Lewis, Edward, Box 177, Mt. Shasta, Calif.
'34 Lewis, J. C., Tahoe City, Calif.
'35 Lewis, R. C., Hot Creek Rearing Ponds, Bishop, Calif.
'27 Lilly, Eugene, The Lilly Ponds, 14 Alsace Way, Colorado Springs, Colo.
'30 Lincoln, Guy, Boyne City, Mich.
'32 Lindner, Milton J., 117 New Orleans Court Bldg., New Orleans, La.
'20 Lindsay, R. Charles, Gaspé, P. Q., Canada.
'34 Littlefield, J. E., 200 South Main St., Brewer, Me.
'37 Lloyd, Charles N., Woodruff, Wis.
'30 Locke, Fred E., Institute for Fisheries Research, University Museums, Ann Arbor, Mich.
'22 Locke, Samuel B., Park Square Bldg., Boston, Mass.
'32 Long, Louis J., Marlinton, W. Va.
'33 Looff, A. T., U. S. Bureau of Fisheries Station, Quinault, Wash.
'37 Louchet, Clementin, 9 Boulevard Maignan-Lariviere, 9, Amiens, France.
'31 Loutit, Hon. W. H., Chairman, Conservation Commission, Lansing, Mich.
'32 Lucas, Clarence R., 3816 Jocelyn St., Washington, D. C.
'37 Luzader, G. P., Route 5, Box 834, South Tacoma, Wash.
'37 Lynch, James E., University of Washington, Seattle, Wash.
'27 McCay, Dr. C. M., Animal Husbandry Dept., Cornell Univ., Ithaca, N. Y.
'38 McCleod, Ross A., Kaweeh State Fish Hatchery, Three Rivers, Calif.
'38 McCloud, George, Independence, Calif.
'39 McCormick, Elizabeth M., 667 Berkeley Rd., Columbus, Ohio.
'38 McCully, Howard, 1035 Bryant St., Palo Alto, Calif.
'29 McDowell, Robert H., Crawford, Neb.
'38 McGhee, J. P., Div. of Fish and Game, Burney, Calif.
'30 M'Gonigle, Dr. R. H., Atlantic Biological Station, St. Andrews, N. B., Canada.
'30 McKenzie, R. A., Fisheries Experiment Station, Kings Wharf, Halifax, N. S., Canada.
'20 McKinney, Robert E., 16 Rosecliff St., Roslindale, Mass.
'34 McNamara, Fred, Howell, Mich.
'27 MacDonald, Kenneth F., 3317 2nd Ave., N., Billings, Mont.
'26 MacKay, H. H., East Block, Parliament Bldg., E. 137, Toronto, Ont., Canada.
'35 Maclay, David J., Lo Lo, Mont.
'36 Madsen, David H., 414 Boston Bldg., Salt Lake City, Utah.
'38 Mailman, Harold B., U. S. Fisheries Station, Saratoga, Wyo.
'36 Makepeace, J. C., Box 126, Wareham, Mass.
'38 Manges, D. Edmund, U. S. Forest Service, Cleveland, Tenn.
'37 Mann, Lloyd, R. F. D. No. 1, Dundee, Ill.
'11 Marine, Dr. David, Montefiore Home and Hospital, Gun Hill Rd., East 210th St., New York, N. Y.
'30 Markus, Henry C., Municipal Museum, Edgerton Park, Rochester, N. Y.
'38 Masters, Charles Otto, 3155 West 11th St., Cleveland, Ohio.
'21 Matthews, J. H., Ex-Sec., Middle Atlantic Fisheries Assn., 203 Front St., New York, N. Y.
'38 Maynard, Vess, Livingston, Tenn.
'28 Meehean, O. Lloyd, Welaka, Fla.
'26 Meredith, C. J., Bowling Green, Ky.

'38 Merrill, Herbert Ream, Mt. Shasta, Calif.
'30 Merritt, J. M., State Fisheries, Gretna, Neb.
'13 Mershon, W. B., Saginaw, Mich.
'37 Meyer, Marcus S., Carson, Wash.
'35 Meyer, Marcus W., U. S. Fisheries Station, Box 13, Quinault, Wash.
'33 Millar, Eric A., P. O. Box 490, Montreal, Canada.
'36 Miller, C. Blackburn, 103 Alta Ave., Yonkers, N. Y.
'37 Miller, Lawrence F., Box 392, Decatur, Ala.
'32 Miller, Ralph W., Accident, Md.
'27 Mitchell, Dr. James F., Pachacayo, Peru, South America.
'24 Mix, Oliver, State Fish Hatchery, St. Paul, Minn.
'20 Money, Gen. Noel, Qualicum Beach, B. C., Canada.
'32 Montgomery, George N., East Orland, Me.
'31 Moody, Ervin, Box 86, Drayton Plains, Mich.
'18 Moore, Dr. Emmeline, Conservation Commission, Albany, N. Y.
'37 Moore, George Azro, Oklahoma A. & M. College, Stillwater, Okla.
'37 Morcher, Charles, State Fish Farm No. 3, London, Ohio.
'26 Morgan, Henry, East Islip, N. Y.
'34 Morisset, Paul, 56 des Erables, Quebec, Canada.
'34 Morofsky, Walter F., Box 771, East Lansing, Mich.
'39 Morse, L. Glen, U. S. Fisheries Station, Dexter, N. Mex.
'20 Motherwell, Major J. A., Dept. of Marine and Fisheries, Rogers Bldg., Vancouver, B. C., Canada.
'34 Mottley, Dr. C. McC., Comstock Hall, Cornell University, Ithaca, N. Y.
'39 Mottley, W. Douglas, 2167 West 36th Ave., Vancouver, B. C., Canada.
'38 Muller, Mark T., 710 Stewart Ave., Ithaca, N. Y.
'36 Myers, Dr. George S., Natural History Museum, Stanford University, Calif.
'30 Nachman, Fred, Park Rapids, Minn.
'18 Needham, Prof. James G., Cornell University, Ithaca, N. Y.
'28 Needham, Dr. Paul R., Stanford University, Palo Alto, Calif.
'37 Nelson, A. L., State Fish Hatchery, Redby, Minn.
'33 Nesbit, Robert A., U. S. Bureau of Fisheries, College Park, Md.
'37 Newcomb, Hugh Ross, 380 Dedham St., Newton Center, Mass.
'34 Newcomb, Dr. W. E., 1532 Keith Bldg., Cleveland, Ohio.
'37 Norris, Russell T., 1 North Atkinson St., Newburyport, Mass.
'13 Oakes, William H., 24 Union Park St., Boston, Mass.
'34 Odell, Ralph W., 53 N. Main St., Franklinville, N. Y.
'29 Odell, Theodore, Hobart College, Geneva, N. Y.
'37 O'Donnell, D. John, Dept. of Conservation, Spooner, Wis.
'36 Olson, Herman F., U. S. Forest Service, Federal Bldg., Duluth, Minn.
'28 Olson, Theodore A., Minn. Dept. of Health, Div. of Sanitation, Univ. of Minn., Minneapolis, Minn.
'36 Osgood, Wayland, Dept. of Conservation, Lansing, Mich.
'38 Pasko, Donald G., State Fish Hatchery, Gloversville, N. Y.
'36 Patterson, Matt, 329 North Cedar St., Sturgeon Bay, Wis.
'35 Pautzke, Clarence F., Dept. of Game, Lloyd Bldg., Seattle, Wash.
'39 Peacock, Dr. Alfred B., Irving Bldg., Marshfield, Ore.
'32 Pells, Frank, Cultus Lake Hatchery, Vedder Crossing, B. C., Canada.
'28 Pelnar, John, U. S. Bureau of Fisheries, Quilcene, Wash.
'37 Pelton, John Z., 94 E. Tulane Rd., Columbus, Ohio.
'37 Perlmutter, Alfred, U. S. Bureau of Fisheries, Biological Institute, Cambridge, Mass.
'36 Perrin, A. F., Hunter Bldg., Dept. of Fisheries, Ottawa, Canada.
'38 Perry, Lorin Edward, U. S. Bureau of Fisheries, Utah State Agriculture College, Logan, Utah.
'30 Phillips, Dr. Alfred N., Middlesex Rd., Glenbrook, Conn.
'37 Phillips, Julius B., Hopkins Marine Station, Pacific Grove, Calif.
'37 Pickering, Loring, Pacific-Union Club, San Francisco, Calif.

'38 Pollitt, Allan F., Div. of Fish and Game, Orick, Calif.
'13 Poole, Gardner, 3 Commercial St., Boston, Mass.
'36 Potts, Floyd W., Harrisville, Mich.
'25 Powell, Albert M., Lewistown, Md.
'37 Powers, Dr. Edwin B., Dept. of Zoology, University of Tennessee, Knoxville, Tenn.
'36 Prefontaine, Georges, University of Montreal, Montreal, P. Q., Canada.
'33 Prevost, Gustave, McGill University, Montreal, Canada.
'31 Pritchard, Dr. A. L., Pacific Biological Station, Nanaimo, B. C., Canada.
'32 Prytherch, Dr. Herbert F., U. S. Fisheries Biological Station, Beaufort, N. C.
'37 Pugsley, Winfield B., 47-53 South Water St., Peekskill, N. Y.
'35 Pullum, Lloyd T., U. S. Fisheries Station, Saratoga, Wyo.
'29 Quinn, I. T., Alban Towers, Washington, D. C.
'37 Randle, Allan C., U. S. Forest Service, Ydalpom, Calif.
'37 Raney, Edward C., McGraw Hall, Cornell University, Ithaca, N. Y.
'36 Rayner, H. John, Museum of Natural History, Stanford University, Palo Alto, Calif.
'38 Reeve, Edward H., State Fish Hatchery, Unionville, Conn.
'33 Regan, C. C., 3920 Tracy Ave., Covington, Ky.
'37 Reid, Kenneth A., 222 N. Bank Drive, Chicago, Ill.
'93 Reighard, Prof. Jacob E., University of Michigan, Ann Arbor, Mich.
'38 Rich, Dr. Willis H., Natural History Museum, Stanford University, Calif.
'24 Richard, L. A., Dept. Colonization, Mines and Fisheries, Quebec, Canada.
'34 Richardson, Dr. Laurence R., Dept. of Biology, Victor University College, Wellington, N. Z.
'36 Ricker, Dr. William E., Zoology Dept., Indiana University, Bloomington, Ind.
'34 Rivero, Luis Howell, Museo Poey, Universidad de la Habana, Cuba.
'33 Roach, Lee S., Dept. of Conservation, Columbus, Ohio.
'35 Robertson, Alexander, Cultus Lake Hatchery, Vedder Crossing, B. C., Canada.
'19 Rodd, J. A., Department of Fisheries, Ottawa, Canada.
'20 Rodd, R. T., 9203 99th St., Edmonton, Alberta, Canada.
'35 Rodeheffer, I. A., 16724 Harbor St., Detroit, Mich.
'38 Roecher, Alan W., Madison, Wis.
'39 Roelofs, Eugene W., 114 Charles St., East Lansing, Mich.
'33 Roff, George W., U. S. Fisheries Station, Manchester, Iowa.
'34 Rogers, Carleton, 127 N. Main St., Porterville, Calif.
'38 Roith, Raymond, 849 Thomas St., St. Paul, Minn.
'38 Roth, A. R., Idaho State Fish and Game Dept., Boise, Idaho.
'34 Royce, J. S., Warrensburg, N. Y.
'35 Royce, William F., Comstock Hall, Cornell University, Ithaca, N. Y.
'35 Rumsey, William L., Jr., 128 Vanderbilt Hall, Harvard Medical School, Boston, Mass.
'37 Rushton, Dr. Wilfred, Salmon and Trout Assn., Fishmongers Hall, London Bridge, London E.C. 4, England.
'38 Ryan, C. D., U. S. Fisheries Station, Springville, Utah.
'39 Sadler, Charles Webb, Sandusky, Ohio.
'35 Sauheitl, Louis, State Fish Hatchery, Marquette, Mich.
'38 Scattergood, Leslie W., U. S. Bureau of Fisheries, Booth Bay, Me.
'37 Schaefer, Milner B., International Pacific Salmon Investigation, New Westminster, B. C., Canada.
'34 Schlotman, Joseph B., 1818 Ford Bldg., Detroit, Mich.
'34 Schneberger, Dr. Edward, Conservation Department, Madison, Wis.
'38 Schuck, Howard A., 12 Lily St., Newburgh, N. Y.
'34 Schultz, Dr. Leonard P., U. S. National Museum, Washington, D. C.
'15 Scofield, N. B., Div. of Fish and Game, Ferry Bldg., San Francisco, Calif.
'32 Scofield, W. L., State Fisheries Laboratory, Terminal Island, Calif.
'36 Scott, J. H., 639 Merchants Exchange Bldg., San Francisco, Calif.
'37 Scott, Dr. John W., Game and Fish Commission, Cheyenne, Wyo.

'35 Scott, William, Fish Farm No. 12, Kincaid Springs, Latham, Ohio.
'27 Seale, Alvin, Supt., Steinhart Aquarium, Golden Gate Park, San Francisco, Calif.
'30 Senning, W. C., McGraw Hall, Cornell University, Ithaca, N. Y.
'23 Sette, Oscar E., Stanford University, Palo Alto, Calif.
'33 Shapovalov, Leo, Natural History Museum, Stanford University, Palo Alto, Calif.
'37 Shattuck, Otis E., Wenham Rd., Topsfield, Mass.
'38 Shaw, Paul A., Div. of Fish and Game, Ferry Bldg., San Francisco, Calif.
'39 Shawhan, H. W., Conservation Com., Charleston, W. Va.
'31 Sheehan, J. P., State Fish Hatchery, Hamilton, Mont.
'13 Shelford, Dr. Victor E., 506 West Iowa St., Urbana, Ill.
'38 Shelley, Edwin, Glenwood, N. Mex.
'36 Shetter, Dr. David S., University Museums, Ann Arbor, Mich.
'32 Shillington, K. G., Frasers Mills, N. S., Canada.
'08 Shiras, George, 3d, 460 E. Ridge St., Marquette, Mich.
'35 Shoemaker, Carl D., Normandy Bldg., Washington, D. C.
'38 Shoup, Dr. Charles S., Dept. of Biology, Vanderbilt University, Nashville, Tenn.
'36 Shust, Stanley, State Fish Hatchery, Manistique, Mich.
'30 Sibley, E. L., Bennington, Vt.
'22 Siems, Allan G., 2575 Como Ave., W., St. Paul, Minn.
'34 Simon, James R., Game and Fish Com., Cheyenne, Wyo.
'39 Simpson, Jack, 521 Davidson Ave., Albuquerque, N. Mex.
'37 Simpson, James C., Game and Fish Commission, Cheyenne, Wyo.
'26 Slade, George T., 9 East 84th St., New York, N. Y.
'34 Smith, Andrew B., Oak Springs Hatchery, Maupin, Ore.
'37 Smith, E. V., Alabama Experiment Station, Auburn, Ala.
'37 Smith, Lloyd L., Jr., University Museums, Ann Arbor, Mich.
'32 Smith, Dr. M. W., Atlantic Biological Station, St. Andrews, N. B., Canada.
'24 Smith, O. Warren, 120 Church St., Oconomowoc, Wis.
'31 Smith, Dr. Osgood R., Natural History Museum, Stanford University, Calif.
'34 Smyth, J. Adger, Salem, Va.
'30 Snipes, Frank L., U. S. Bureau of Fisheries, Flintville, Tenn.
'05 Snyder, J. P., U. S. Bureau of Fisheries, Cape Vincent, N. Y.
'37 Solis, S. Samuel, P. O. Box 54, Veracruz, Ver., Mexico.
'38 Southam, J. D., Calgary Herald, Calgary, Alta., Canada.
'35 Southwick, P. W., Scio, Ore.
'36 Spaulding, M. H., Montana State College, Bozeman, Mont.
'36 Speaker, E. B., State Conservation Commission, 10th and Mulberry, Des Moines, Iowa.
'21 Spencer, H. B., 1101 Vermont Ave., Washington, D. C.
'37 Spinner, Norbert, Lansing, Iowa.
'36 Spoor, Dr. W. A., University of Cincinnati, Cincinnati, Ohio.
'16 Spragle, L. H., Paradise Brook Trout Co., Cresco, Pa.
'39 Sprecher, George E., 1047 E. Gorham St., Madison, Wis.
'37 Springer, Stewart, Englewood, Fla.
'10 Stack, George F., Paradise Brook Trout Co., Cresco, Pa.
'36 Stapledon, Charles F., Dept. of Fisheries, Ottawa, Canada.
'37 Stephansky, J. D., Dept. of Conservation, Newberry, Mich.
'34 Stewart, A. T., State Fish Hatchery, Drayton Plains, Mich.
'37 Stiles, Earl W., Comstock Hall, Cornell University, Ithaca, N. Y.
'34 Stobie, George J., State House, Augusta, Me.
'36 Stobie, Robert H., Fish and Game Commission, State House, Concord, N. H.
'35 Stone, Udell B., 121 South Union St., Spencerport, N. Y.
'34 Strong, Philip Furnald, New York State Fish Hatchery, Chateaugay, N. Y.
'37 Sullivan, John, State Fish Farm No. 5, Bucyrus, Ohio.
'38 Sumner, Francis H., Convict Creek Experimental Station, Bishop, Calif.
'26 Surber, Eugene, U. S. Fisheries Station, Kearneysville, W. Va.

'24 Surber, Thaddeus, 1539 Dayton Ave., St. Paul, Minn.
'34 Swingle, H. S., Alabama Experiment Station, Auburn, Ala.
'38 Symons, George E., Bird Island Laboratory, Buffalo, N. Y.
'33 Taft, Alan C., Natural History Museum, Stanford University, Calif.
'38 Talbott, Leon A., Mt. Whitney Hatchery, Independence, Calif.
'33 Tarzwell, Dr. Clarence M., Box 404, Decatur, Ala.
'30 Taylor, Dr. B. W., McGill University, Montreal, Canada.
'19 Terrell, Clyde B., Oshkosh, Wis.
'30 Tester, Dr. Albert L., Pacific Biological Station, Nanaimo, B. C., Canada.
'13 Thomas, Adrian, Box 63, Harbor Beach, Mich.
'26 Thomas, R. P., 1621 Kemble St., Utica, N. Y.
'34 Thompson, Fred A., State Fisheries Station, Jemez Springs, N. Mex.
'35 Thompson, Seton H., U. S. Bureau of Fisheries, Washington, D. C.
'18 Thompson, Dr. W. F., International Fisheries Com., University of Washington, Seattle, Wash.
'35 Thorpe, Lyle M., State Board of Fisheries and Game, Hartford, Conn.
'13 Tichenor, A. K., Alaska Packers Assn., 111 California St., San Francisco, Calif.
'38 Tingler, F. A., Atlantic Biological Station, St. Andrews, N. B., Canada.
'38 Topp, Peter, Burney, Calif.
'32 Trautman, Milton B., Stone Laboratory, Put-in-Bay, Ohio.
'34 Tressler, Dr. Willis L., Biology Dept., Univ. of Buffalo, Buffalo, N. Y.
'21 Tresselt, Frederick, Box 26, Thurmont, Md.
'36 Trippensee, R. E., Massachusetts State College, Amherst, Mass.
'33 Troeder, Paul P., Supt., Penn. Forest Brook Trout Co., Kresgeville, Pa.
'20 Truitt, Dr. R. V., University of Maryland, College Park, Md.
'35 Tryon, C. A., Jr., University of Montana, Bozeman, Mont.
'27 Tucker, Will, State Game, Fish and Oyster Commission, Austin, Tex.
'31 Tunison, A. V., Cortland Experimental Hatchery, Cortland, N. Y.
'37 Tuttle, Edward M., U. S. Fisheries Station, Yellowstone Park, Wyo.
'36 Underhill, A. Heaton, Comstock Hall, Ithaca, N. Y.
'38 Vaill, Charles B. H., 17 Haynes St., Hartford, Conn.
'19 Van Cleave, Prof. H. J., University of Illinois, Urbana, Ill.
'37 Van Leur, Al., Woonsocket, S. Dak.
'35 Van Nuys, J. B., 400 I. N. Van Nuys Bldg., Los Angeles, Calif.
'28 Van Oosten, Dr. John, U. S. Bureau of Fisheries, University Museums, Ann Arbor, Mich.
'36 Ver Duin, Claude, 110 Williams St., Grand Haven, Mich.
'38 Vestal, Elden H., Div. of Fish and Game, June Lake, Calif.
'37 Videla, Dr. Pedro H. Bruno, Piscicultura, San Carlos de Bariloche, Argentine, S. A.
'19 Viosca, Percy, Jr., Southern Biological Supply Co., 517 Decatur St., New Orleans, La.
'36 Vladykov, Dr. Vadim D., Dept. of Mines and Fisheries, Quebec, Canada.
'39 Vogt, James H., Ferry Bldg., San Francisco, Calif.
'29 Voizard, Armand, 842 Boulevard Gouin East, Montreal, Canada.
'39 Volk, Lloyd E., Ohio Wesleyan University, Delaware, Ohio.
'37 Waalen, Milo, State Fish Hatchery, Glenwood, Minn.
'19 Wagner, John, 233 Dock St., Philadelphia, Pa.
'36 Wahl, Leif, 4032 - 20th S. W., Seattle, Wash.
'33 Wales, Joseph H., Box 124, Mt. Shasta, Calif.
'38 Wallace, David, Chesapeake Biological Laboratory, Solomons Island, Md.
'16 Wallace, Frederick William, Gardenvale, P. Q., Canada.
'37 Warfel, Herbert E., Fish and Game Dept., Concord, N. H.
'38 Wascke, Harold L., State Fish Farm No. 1, St. Marys, Ohio.
'38 Washburn, David L., Supt., Coleman Lake Club, Goodman, Wis.
'39 Waters, Don, Ohio Div. of Conservation, Columbus, Ohio.
'38 Weaver, Andrew J., Div. of Fish and Game, Mt. Shasta, Calif.
'33 Weaver, George, Game and Fish Dept., St. Paul, Minn.

'33 Webb, G. C., Alsea Trout Hatchery, Philomath, Ore.
'21 Webster, B. O., Conservation Department, Madison, Wis.
'37 Webster, Dwight A., 82 Hartwell St., Southbridge, Mass.
'37 Welander, Arthur D., University of Washington, Seattle, Wash.
'35 Wells, Rennie E., North Unit Pumping Station, Helena, Mont.
'33 Wendt, L. W., 301 Fourth Ave., N., Great Falls, Mont.
'24 Westerman, Fred A., Department of Conservation, Lansing, Mich.
'35 Westfall, Bertis A., 1405 Anthony, Columbia, Mo.
'37 Wheatley Charles A., 617 Maverick Bldg., San Antonio, Tex.
'38 White, Clark, White's Trout Farm, Paradise, Utah.
'30 White, H. C., Atlantic Biological Station, St. Andrews, N. B., Canada
'39 Whiteman, Haskell W., U. S. Fisheries Station, Butte Falls, Ore.
'37 Whitesel, L. Edward, 3304 - 59th S. W., Seattle, Wash.
'35 Wickersham, J. A., Log Cabin, Colo.
'19 Wickliff, Edward L., Fish and Game Division, Columbus, Ohio.
'25 Wicks, Judson L., 405 Essex Bldg., Minneapolis, Minn.
'34 Widmyer, E. R., U. S. Fisheries Station, Northville, Mich.
'37 Widner, John E., State Fish Farm No. 2, Newtown, Ohio.
'37 Wightman, F. Arnold, 225 Northumberland St., Fredericton, N. B., Canada
'26 Wilcox, T. Ferdinand, 40 Wall St., New York, N. Y.
'38 Wilding, James L., 2725 Montlake Blvd., Seattle, Wash.
'35 Wilkinson, James T., State Fish Hatchery, Oden, Mich.
'36 Williamson, Lyman O., Conservation Department, Woodruff, Wis.
'01 Wilson, C. H., 82 Ridge St., Glens Falls, N. Y.
'38 Wilson, John N., Dept. of Health, Div. of Sanitation, Minneapolis, Minn.
'34 Wilson, Malcolm E., Basin Creek State Fish Hatchery, Tuoluane, Calif.
'37 Wilson, Samuel, R. No. 1, Baltimore, Ohio.
'28 Winkler, W. G., Armour & Co., Union Stock Yards, Chicago, Ill.
'00 Winn, Dennis, 22 Fifield St., Nashua, N. H.
'33 Winslow, L. D., State Fish Hatchery, Bath, N. Y.
'31 Wolf, Dr. Louis Edward, State Fish Hatchery, Rome, N. Y.
'35 Wooddell, L., Ravena, Ohio.
'19 Wright, Prof. Albert Hazen, Cornell University, Ithaca, N. Y.
'33 Wright, Alice I., Pine Road, R. F. D. Box 53, Briarcliff Manor, N. Y.
'30 Wright, Dr. Stillman, U. S. Bureau of Fisheries, Utah State Agricultural College, Logan, Utah.
'37 Yaw, H. M., 1305 3d Ave., North, Great Falls, Mont.
'37 Yingling, W. A., State Fish Farm No. 1, St. Marys, Ohio.
'28 Yorke, R. H., Usk, Wash.
'39 Youmans, Fred A., Washington Game Hatchery, Spokane, Wash.
'23 Young, Floyd S., Lincoln Park Zoo, Chicago, Ill.
'35 Ziesenhenne, Fred C., Box 650, Eugene, Ore.
'36 Zinser, Señor Juan, Game and Fish Dept., Mexico City, Mexico.

## STATE MEMBERSHIP

'35 Alabama Department of Conservation of Game and Seafoods, Dr. Walter B. Jones, Com'r., Montgomery, Ala.
'37 Arizona Game and Fish Commission, Phoenix, Ariz.
'37 Arkansas State Game and Fish Commission, State Capitol Bldg., Little Rock, Ark.
'35 California Fish and Game Commission, Ferry Bldg., San Francisco, Calif.
'24 Colorado State Game and Fish Commission, R. G. Parvin, Com'r., Denver, Colo.
'22 Connecticut Board of Fisheries and Game, State Capitol, Hartford, Conn.
'37 Delaware Board of Game and Fish Commissioners, Dover, Del.
'35 Idaho Department of Fish and Game, Boise, Ida.
'26 Illinois Department of Conservation, Springfield, Ill.
'21 Indiana Division of Fish and Game, Indianapolis, Ind.
'21 Iowa State Conservation Commission, Des Moines, Iowa.
'35 Kansas Forestry, Fish and Game Commission, Pratt, Kan.
'33 Kentucky Division of Game and Fish, Frankfort, Ky.
'21 Louisiana Department of Conservation, New Orleans, La.
'26 Maine Dept. of Inland Fisheries and Game, State House, Augusta, Me.
'22 Maryland Conservation Department, 516 Munsey Bldg., Baltimore, Md.
'21 Massachusetts Division of Fisheries and Game, 20 Somerset St., Boston, Mass.
'37 Mexico Game and Fish Department, Mexico City, Mexico.
'37 Michigan Commission of Conservation, Lansing, Mich.
'21 Minnesota Department of Conservation, State Office Bldg., St. Paul, Minn.
'37 Mississippi State Game and Fish Commission, Jackson, Miss.
'31 Missouri State Conservation Commission, Jefferson City, Mo.
'35 Nebraska Game, Forestation and Parks Commission, Lincoln, Neb.
'37 Newfoundland Dept. of Natural Resources, St. John's, Newfoundland.
'33 New Hampshire Fish and Game Com., Robert H. Stobie, Concord, N. H.
'25 New Jersey State Fish and Game Commission, Trenton, N. J.
'35 New York Conservation Department, Albany, N. Y.
'35 North Carolina Development, Division of Game and Inland Fisheries, J. D. Chalk, Com'r, Raleigh, N. C.
'26 Oklahoma State Game and Fish Commission, Oklahoma City, Okla.
'38 Oregon Game Commission, 616 Oregon Building, Portland, Ore.
'35 Pennsylvania Board of Fish Commissioners, Harrisburg, Pa.
'38 South Carolina Department of Game and Fish, Columbia, S. C.
'35 South Dakota Department of Game and Fish, Pierre, S. D.
'38 Tennessee Department of Conservation, Nashville, Tenn.
'38 Texas Game, Fish and Oyster Commission, Austin, Tex.
'36 Vermont Fish and Game Service, State Office Building, Montpelier, Vt.
'35 Virginia Commission of Game and Inland Fisheries, Richmond, Va.
'38 Washington State Game Commission, Seattle, Wash.
'35 West Virginia Conservation Commission, Charleston, W. Va.
'23 Wisconsin Conservation Department, Madison, Wis.
'27 Wyoming Game and Fish Commission, Cheyenne, Wyo.

---

## CLUBS, DEALERS, ETC.

'27 American Fork & Hoe Co., Geneva, Ohio.
'38 American Wildlife Institute, 822 Investment Bldg., Washington, D. C.
'32 Anglers' Club of New York, William L. Woodward, Treas., 52 Wall Street, New York, N. Y.
'35 Arundel Corporation, Pier 2, Pratt St., Baltimore, Md.
'31 Balto Laboratories, 621 South Fries Ave., Wilmington, Calif.

'37 Chittenden County Fish and Game Club, Inc., 26 University Terrace, Burlington, Vt.
'37 Fishermen's Cooperative Association, Municipal Fish Wharf, San Pedro, Calif.
'32 Gatineau Fish and Game Club, 205 Victoria Bldg., Ottawa, Ont., Canada.
'27 Gladding & Co., Inc., B. F., South Otselic, N. Y.
'30 Heinzerling, C. H., Creek Chub Bait Co., Garrett, Ind.
'28 Johnston, William Douglas, Park House, Montrose, Scotland.
'26 Mashpee Trout Club, J. W. Farley, Treas., 1 Federal St., Boston, Mass.
'22 Massachusetts Fish and Game Association, David A. Aylward, Sec., 20 Spruce St., Boston, Mass.
'27 Mills & Sons, William, 21 Park Place, New York, N. Y.
'23 Nickerson, John C., Gilbert Trout Hatchery, P. O. Box 124, Plymouth, Mass.
'21 Paradise Brook Trout Company, Cresco, Pa.
'21 Pennsylvania State Fish and Game Protective Association, E. W. Nicholson, Pres., Land Title Bldg., Philadelphia, Pa.
'27 Plymouth Rock Trout Co., Box 75, Plymouth, Mass.
'11 Pohoqualine Fish Association, Charles C. Townsend, Sec., Provident Trust Bldg., Philadelphia, Pa.
'21 Porter's Lake Hunting and Fishing Club, Fred W. Wagner, Sec., 925 West Huntington St., Philadelphia, Pa.
'39 Province of Quebec Association for the Protection of Fish and Game, Inc., E. A. Cartier, Sec., 1154 Beaver Hall Sq., Montreal, Canada.
'30 Seigniory Club, J. L. Jorgensen, Supt. of Fisheries, Box 54, Montebello, P. Q., Canada.
'35 Sharon Fish and Game Club, Inc., L. Leaman Currier, Sec., East Street, opp. Billings, Sharon, Mass.
'35 Smith Bros., Port Washington, Wis.
'25 Southside Sportsmen's Club, Oakdale, L. I., N. Y.
'35 Tulsa Anglers' Club, A. D. Aldrich, Pres., 2879 East Archer, Tulsa, Okla.
'35 Turlock Sportsman's Club, Otto E. Zimmerman, Sec., 5 East Main St., Turlock, Calif.
'37 United Fishermen's Union of the Pacific, 212 West 6th St., San Pedro, Calif.
'26 U. S. Fisheries Association, 196 Water St., New York, N. Y.
'37 Valley City Milling Company, Portland, Mich.
'38 Von Hoffman Press Club, 101 South 9th St., St. Louis, Mo.
'28 Weber Lifelike Fly Co., Stevens Point, Wis.
'39 Western Bass Club, 222 Broadway North, Seattle, Wash.

## LIBRARIES

'21 Academy of Natural Sciences of Philadelphia, Logan Square, Philadelphia, Pa.
'23 American Museum of Natural History, 77th St. and Central Park West, New York, N. Y.
'20 Atlantic Biological Station, St. Andrews, N. B., Canada.
'37 Billings Library, University of Vermont, Burlington, Vt.
'28 Library, Bureau of Education and Research, Division of Fish and Game, Ferry Bldg., San Francisco, Calif.
'21 California State Fisheries Laboratory Library, Terminal, Calif.
'36 Connecticut State College, Storrs, Conn.
'36 Enoch Pratt Free Library, Cathedral, Franklin and Mulberry Sts., Baltimore, Md.
'36 Public Library, C. E. Evans, Librarian, Erie, Pa.
'37 Fisheries Section, Fisheries Reservation, Cronulla, New South Wales.
'37 Fishery Research Institute, P. O. Box 728, St. John's, Newfoundland.

'36 Food Technical Bureau, Amtorg Trading Corp., 261 Fifth Ave., New York, N. Y.
'37 Freshwater Biological Association Library, Wray Castle, Ambleside, Westmoreland, England.
'38 Hamilton Smith Library, University of New Hampshire, Durham, N. H.
'20 Harvard University Library, Cambridge, Mass.
'38 Institute of Zoology, University of Montreal, 1265 St. Debis St., Montreal, Canada.
'21 John Crerar Library, 86 East Randolph St., Chicago, Ill.
'38 Lincoln Memorial University Library, Harrogate, Tenn.
'35 Massachusetts State Library, State House, Boston, Mass.
'36 McGill University, Redpath Library, 3459 McTavish St., Montreal, P. Q., Canada.
'38 Montana State University, Missoula, Mont.
'37 Mount Holyoke College Library, South Hadley, Mass.
'18 New York Public Library, 476 Fifth Ave., New York, N. Y.
'22 New York State College of Agriculture Library, Ithaca, N. Y.
'18 New York State Library, Albany, N. Y.
'22 Ohio State University Library, Columbus, Ohio.
'36 Oklahoma A & M College, Stillwater, Okla.
'27 Library, Oregon State Agricultural College, Corvallis, Ore.
'38 Pacific Biological Station, Nanaimo, B. C., Canada.
'22 Library Association of Portland, 10th and Yamhill Sts., Portland, Ore.
'37 Library of the Legislature, Quebec, P. Q., Canada.
'36 Queen's University Library, Kingston, Ont., Canada.
'22 Scientific Library Division, P. O. Box 774, Manila, P. I.
'21 Scripps Institution of Oceanography, La Jolla, Calif.
'38 U. S. Fisheries Laboratory Library, 2725 Montlake Blvd., Seattle, Wash.
'35 U. S. Forest Service Library, 7173 Plankinton Arcade Bldg., Milwaukee, Wis.
'37 University of California, Berkeley, Calif.
'22 University of Illinois, Urbana, Ill.
'20 University of Indiana Library, Bloomington, Ind.
'36 University of Maine, Orono, Me.
'20 University of Michigan Library, Ann Arbor, Mich.
'21 University of Nebraska Library, Lincoln, Neb.
'38 University of Saskatchewan, Saskatoon, Sask., Canada.
'21 University of Toronto Library, Toronto, Canada.
'19 University of Washington Library, Seattle, Wash.
'39 W. K. Kellogg Bird Sanctuary, Augusta, Mich.
'20 Yale University Library, New Haven, Conn.

---

## CORRESPONDING MEMBERS

'22 Director, All-Russian Agricultural Museum, Fontanka 10, Leningrad, U.S.S.R.
'22 Director of Fisheries (British Malay), Singapore, Straits Settlements.
'22 Library, National Museum of Natural History, Paris, France.
'10 Stead, David G., Watsons Bay, New South Wales, Australia.

# INSTRUCTIONS FOR PREPARING AND EDITING MANUSCRIPTS FOR THE TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY

**(REVISED 1940)**

Please check each item below before the final typing of your manuscript and help your Society reduce the costs of publication, save your Editorial Committee (which works gratis) much needless work, time, and expense, and avoid delay in the publication of the Transactions.

The following instructions were not drawn up arbitrarily but were condensed from the regulations contained in the best style manuals (Government Printing Office Style Manual; University of Chicago Style Manual). Certain instructions may appear unnecessary, but they are nevertheless essential for the proper handling of materials by the printer and the editor.

## I. MECHANICAL DETAILS

1. **Manuscript must be typewritten double-spaced.** Use one side only of sheet. Do not fold manuscript.

2. **Carbon copies will not be accepted.** Do not use thin, transparent paper. Heavy bond paper is preferred.

3. **Margins** at top, bottom, and both sides should be about 1½ inches to allow space for necessary corrections by editor.

4. **Pages** must be numbered in consecutive order, including the bibliography, tables, charts, and photographs. Tables, charts, and all illustrations must be inserted near their place of reference in the text.

5. **Illustrations.** Make separate pages of tables with headings (not of leader work), of diagrams, charts, and illustrations, and limit the number to those absolutely necessary to clarify or supplement text. *Tables and cuts cost money!* Only sharp, glossy photos can be used. All drawings, charts and diagrams should be prepared in waterproof India ink on Bristol Board, other perfectly smooth white paper or cardboard, or tracing cloth. Graph paper must not be used. No erasures should be made. Shading should be limited to a minimum and when used the shading lines should be kept open. The curves of graphs should be drawn much bolder than any guide lines or ruling. Lettering should be bold and sufficiently large and spaced apart so that the letters or numbers will not be less than 1 millimeter high or come in contact when reduced. Drawings should be made at least twice the size required for reproduction, and when large should be of proper proportion so that they will not exceed 4¼ by 6½ inches (inclusive of legends) when reduced. All explanatory matter other than the units along each axis of a graph or diagram and those designations needed for clarity should be placed in the legend. The legend, which should be typewritten on a separate sheet, will be set in type below the figure.

Make proper reference in text to all plates, figures, maps, charts, and tables, and designate all of these, except tables, as figures, numbering them in consecutive order with Arabic, not Roman, numerals.

6. **Footnotes** in text should be numbered consecutively and should be placed immediately after the full line of text in which the reference mark occurs, but do not break a line of text to insert footnote. Separate the footnote from the

text by two horizontal lines, one above and one below the note. In each new table footnotes should begin with 1.

7. **The title** of the manuscript, together with the author's name (write out in full either one or both of the Christian names and do not use the word "by"), position or department, and post office address, should always appear at the top of the first page of the manuscript as follows, allowing at least *triple space between lines* to permit the insertion of instructions to the printer:

REPORT ON THE DISEASES OF BROOK TROUT

JOHN EDWARD DOE
*Department of Conservation, Lansing, Michigan*

8. **Underscore** (italics) all scientific names of genera and species, both animals and plants, in both text and tables. Do not underscore or use all capital letters for scientific names of an order higher than the genus: Esocidae; *Esox lucius. Do not underscore unless italics are intended.*

9. Inspect papers in the last volume of the Transactions if you have questions concerning the arrangement of materials.

## II. STYLE

10. **Bibliographic references** in text should give name of author and year of publication in parentheses, thus (Doe, 1932). Do not use letters or numbers or footnotes for references. If more than one publication by the same author is given for a year, use the alphabet to designate the correct paper, thus (Doe, 1932a) or (Doe, 1932b). In the bibliography do not repeat the author's name if reference is made to more than one of his publications, but list his publications in chronological order beginning with the earliest one. In citing a joint publication invert the name of the senior author but not of the co-author or co-authors. *Do not include any references not mentioned in the text.* List authors in alphabetical sequence. Capitalize the first word and proper names only in the title. Follow the arrangement given below to be placed at end of paper:

Literature Cited

Doe, John C., J. W. Brown, and H. W. Green.
1939. Report on the diseases of brook trout. Trans. Am. Fish Soc., 1938, Vol. 68, pp. 450-461.

Note that the year of publication precedes the title and the year of the meeting is stated in the reference.

Please check your references carefully as to titles, spelling, capitalization, italics, diacritical marks, abbreviations, etc., against their original sources, after the final typing, and *state beneath your bibliography that you have done so.* Many bibliographic titles published in the Transactions have been found to be incomplete and very inaccurate. Help us correct this situation.

11. **Tables.** Every table should have a heading and must be typewritten on a separate page. Insert tables among the text pages near the points where they are discussed. Number tables consecutively with Arabic, not Roman, numerals (1, 2, 3, etc.). Abbreviate the word "number" (No.) when referring to a special number—not when referring to quantity or things. Spell all other words in tables, including such words as "millimeters," "ounces," and "average" (except months *with date*, in body of table), and capitalize, as a rule, the first word only in headings in the first column or over other columns. Precede all decimal numbers with zero. Use dollar sign only with first number at top of column and under each cross rule. Note that no vertical lines are used to separate columns!

| Item | Number of fish | Percentage of total | Average length in millimeters | Months | Cost of diet per pound |
|---|---|---|---|---|---|
| Brook trout surviving experiment No. 2 | 23 | 5.8 | 6.5 | April-September | $0.05 |

12. **Capitals.** Capitalize words when used as part of a proper name or of an identifying number or letter, or when referring to a particular State, Government, and to organized bodies, or when used as proper names. For example: Lake Michigan, State of Michigan, or the State, the Province, the Republic, or the National and State Governments, Washtenaw County, Ann Arbor Township, Huron River, Pacific Ocean, North Atlantic, Northern States, Reservoir No. 1, Boulder Dam, Pond No. 1 or Pond A, State Fish Farm No. 1, Pisgah National Forest, American Fisheries Society.

Capitalize names of sections of the United States, or of any other country, as Middle West, but lower-case a term prefixed to any such sections, as eastern North Atlantic States.

Capitalize any term (except page or pages and age group) preceding Roman numerals, as Article I, Chapter II, Sample VI, etc. Also capitalize such terms as Appendix 1 or Appendix A, Experiment 2, Table 4, and Figure 8 (referring to illustrations).

Use lower case for scientific and common names of species. Capitalize scientific names of higher orders.

13. **Abbreviations.**

(a) Abbreviate the following:

*Clock time,* if connected with figures—2:30 a.m.

*Temperatures*—F. (Fahrenheit).

*Degrees,* whether referring to temperatures, longitude and latitude, or angles, etc.—75°, 75° F., 75° C.

*"Number,"* when preceding figures—No. 125; otherwise spell out.

*"United States,"* if preceding name of a department or a bureau or a vessel, etc.—U. S. Bureau of Fisheries, U. S. S. *Indiana.*

*Months,* in body of tables and footnotes to same when followed by day of month—Apr. 5-Sept. 2 (but April-September).

(b) Do not abbreviate the following:

*States, cities, etc.*

*Months,* in text or in headings of tables—April 5-September 2.

*Measures and weight, except p.p.m.*—6 inches, 20 millimeters, 5 ounces, 1.5 acres, etc.

*Percentage*—12 per cent, a percentage of 25.5.

14. **Numerals.** Spell out all *isolated* numbers less than 10, but use figures in a group of enumerations when any one number of that group is 10 or greater. Do not spell out numbers of two or more digits (except round numbers of approximations: estimated at five hundred; a thousand fish), and always use a comma in a number of four or more digits. Treat alike all numbers in a series of connected groups. For example: There were nine trout. There were 9 trout, 120 bass, and 50 pike.

Use figures for all enumerations of quantities and measurements, such as dimension, weight, area, volume, distance (if fraction spell out, as one-half mile), clock time, time, money, percentage, degrees, proportion or ratios, age, dates, page numbers, decimals, and mixed numbers (spell out common fractions if alone: one-eighth inch). For example: $3.00 per 20 pounds; 5 feet 6 inches; about 10 miles; 6 acres; 15 cubic centimeters; 4:30 p.m.; fish died in 1 hour and 20 minutes at 30

minutes past 4 o'clock; 25.5 per cent; 75° F.; 1:10,000; trout 2 years 6 months old; 2-year-old trout; June 29, 1936; the 1st of January, 1938, the 20th day of March; 1937-38; 4.5 p.p.m.; 0.25; 1½ pages; page 215.

Write 8 by 12, not 8 x 12 unless multiplication is indicated. Write 50-50, not "fifty-fifty."

Do not use two figures when two numbers appear together, unless the first enumeration exceeds 100: ten 12-room houses; twenty 6-inch trout; 120 6-inch trout.

Spell out figures beginning a sentence, but avoid such use of numerals if possible. Spell out both numbers of two related amounts at the beginning of a sentence in such expressions as "Twenty to twenty-five trout," but write "Two hundred fifty bass and 325 trout were shipped."

Spell out such indefinite expressions as the following: Between two and three hundred fish; there were thirty or forty thousand trout.

In expressing large numbers the word *million* (or a similar larger group term) may be spelled out: 20 million, 2¾ billions.

15. **Use of hyphen.** Many compound words when used as nouns are not hyphenated but require use of the hyphen when used as adjectives. For example note the following sentences: "This was *cold water.*" "Trout are *cold-water* fish." Write "fish culture," but "fish-culturist." Check your manuscript carefully for use of hyphen. The words, "subspecies," "upstream" and many other words originally of compound derivation are written without a hyphen.

Write "largemouth" and "smallmouth" as one word when referring to black bass.

## III. SUBJECT MATTER

16. **Condense your paper** to the limit and omit all needless verbiage to reduce cost of printing. The manuscript should be simple, direct, clear, concise, accurate, consistent, and complete. *Accuracy* in subject matter, in scientific names, and in bibliography is especially important. Have your associates read and criticize your paper before the final typing. **Papers which are too poorly written will be rejected.** Do not expect your Editorial Committee to rewrite your manuscript.

17. **Be definite in references to species.** The scientific name, and wherever needed the *complete* common name, that will identify the species about which the paper is written should be included in the title as well as in the text, unless the number of species is too large. Such names as "bass," "trout," "pike," and "pickerel" apply to any one of several species. Do not write "smallmouth," "brook," "rainbow," etc., when you mean "smallmouth black bass," "brook trout," "rainbow trout," etc.

18. **Things to avoid.** The *words* "case," "instance," "show," "found," "gave," and "present" are overworked in manuscripts, the same word sometimes appearing several times in one paragraph.

Avoid the repeated use of *participles* which, as a rule, weaken sentences. In the following illustration note the improvement when the words in parentheses are used: "The principles underlying (that underlie) the production of beef are essentially the same as those involving (that are involved in) the production of bass."

Avoid *split infinitives.* Please check your manuscript for this exceedingly common error.

Avoid the use of *this* and *these* as substantives. Compare, for example, the following two sentences for effectiveness: "*This* was true in every *case.*" "*The mortality was high* in every *pond.*"

19. **Abstract of paper.** Give a condensed summary or brief abstract at the beginning of your paper.

*Prepared by Publications Committee, John Van Oosten, Chairman.*
*February, 1937 (revised 1940).*

# INDEX TO VOLUME 69